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CIVIL ENGINEERING.

On Steam Boilers. By ZERAH COLBURN.

From the Lond. Civ. Eng. and Arch. Journal, Oct., 1864.
Read before the British Association.

THE rate at which heat may be transmitted through an iron boiler plate, without injury to its substance, has never been precisely ascertained. About 70,000 units of heat per hour, equal to the evaporation in that time of one cubic foot of water from 60°, is believed to be the utmost square foot of plate of ordinary thickness. But, in order to approximately apply the *whole* heat of a furnace to the purposes of evaporation, a much larger area of heating surface, per unit of work done, is requisite. Watt fixed the proportion of one square yard of heating surface per cubic foot of water evaporated per hour, and this has been sanctioned by modern practice. But the average depth—or, in other words, the thickness of the stratum—of water thus boiled away is only $1\frac{1}{2}$d in. per hour, $\frac{1}{45}$th inch per minute or $\frac{1}{2700}$th inch per second, over the whole heating surface. From ten to twelve seconds are thus occupied in vaporizing a *couche* of water, no thicker than a single leaf of the paper upon which books are commonly printed. If, in proportion to the evaporation; an insufficient extent of heating surface be provided, there is not only a direct waste of heat—the products of combustion escaping at a temperature corresponding, perhaps, to that of incandescent iron—but the furnace plates may be burnt. Notwithstanding the active convection of heat in water, an intense flame, directed against the sides or roof of a boiler furnace, will, in time,

crack or blister the iron. It is not certain that this result occurs from the inability of the metal to transmit the heat, for it is more likely that, under vigorous evaporation, the gravity of the liquid water (and it is the gravity only that brings it to the heating surfaces) is insufficient to bear down effectually against the rising volumes of steam. If, by powerful mechanical means, the water could be constantly maintained in contact with the heating surfaces, it is possible that the rate of evaporation upon a given area could be increased without injury to the plate. In the hardening of anvil faces and of steel dies, the requisite rapidity of cooling is obtained, not merely by immersing in water, but by its forcible descent in a strong jet upon the heated metal.

Under the conditions, however, of ordinary practice, no restriction of the heating surface is permissible. This surface is sometimes that of the exterior only of the boiler, but it is more usual, and on most accounts preferable, to dispose it internally by means of fire-boxes, flues, or tubes. The external surface of a boiler can only be increased by increasing its length or its diameter, or by increasing both of these together. Plain cylindrical boilers 90 ft., and in one or two instances 104 ft. in length, have been employed, but, even apart from any consideration of the great amount of space which they occupy, they are mechanically objectionable, and they are now no longer made. In increasing the external surface of a boiler by enlarging its diameter, it is weakened exactly in proportion to the increase, the bursting pressure, for a given thickness of plates, being inversely as the diameter. The danger attending the presence of a large quantity of heated water in a boiler is now well understood, and such as it is, it increases as the square of the diameter, so that, in a boiler of a given length, the elements of weakness and danger are collectively related to the cube of the diameter. External heating surface may be provided for in a number of smaller vessels, as in the retort boilers by Mr. Dunn, but these are of the water-tube family, which, heretofore, has been found subject to choking with the solid matter deposited by the water.

Next are the boilers with internal heating surfaces. Internal fire tubes were in use in steam boilers in the last century, and they were applied within a cylindrical barrel by the Cornish engineers, among whom was Trevithick, who employed both the straight flue and the return flue, and who made the fire-place within the flue. The Cornish boiler, in this form, was improved by Mr, Fairbairn and the late Mr. Hetherington, who added another fire tube, thus making the two-flued boiler now so extensively employed in Lancashire. The two flues, although somewhat smaller than the single flue, afforded a greater extent of heating surface, besides securing increased regularity in firing. The principle of subdividing the flame and heated products of combustion, so as to obtain greatly increased heating surface within a barrel of given diameter, was fully carried out in the multitubular boiler invented by Neville, of London, in 1826, employed by Seguin, in France, in 1828, and subsequently in the Liverpool and Manchester locomotives, from which it has been handed down to the present practice of engineers. Not since Watt's time, however, has the evaporative power

of a square foot of heating surface been increased, the improvement in the plan of steam boilers being that, chiefly, of inclosing a greater extent of surface within a given space. The heating surface in the boilers of the *Great Eastern* steamship is equal to the entire area of her vast main deck; that in the *Adriatic* measures more than $\frac{3}{4}$ of an acre; while the *Warrior* and the *Black Prince* have in their boilers 2500 square yards of surface of tubes, the aggregate length of which is more than $5\frac{1}{2}$ miles. But it is only where, as in steamships and locomotive engines, the dimensions and weight of boilers must be the least possible, that the multitubular arrangement is even to be tolerated. It is costly, and subject to rapid decay. In steamships especially, the life of multitubular boilers is comparatively short. The boilers in her Majesty's vessels of war are found to last but from five to seven years; those of the West Indian Royal Mail ships last, according to Mr. Pitcher, of Northfleet, six years only; and those of the Dover and Calais packets taking the testimony of the former mail contractor, Mr. Churchward, need to be renewed every three and a half or four years. On land, multitubular boilers working under a constant strain, and in most cases, as constantly concentrating a saturated solution of sulphate of lime, are nearly out of the question for the purposes of manufactories, although there are instances of their employment even in spinning-mills.

A boiler rated at 40 nominal horse power will ordinarily evaporate 60 cubic feet of water per hour, or upwards of 100 tons of water per week of 60 hours. And feed water, containing as much as 40 grains of solid matter per gallon, is often regarded as very good, not only when the inorganic impurity consists of the deliquescent salts of soda, but even when it is neither more nor less than an obdurate carbonate or sulphate of lime. Whatever the solid matter contained in the water may be, it is never carried over with the steam, but is left behind in the evaporating apparatus, and 100 tons of water, fed in a single week to a boiler in the manufacturing districts commonly contains a hundredweight or more of dissolved gypsum or marble, and of which all that is not held in solution is deposited in a calcareous lining upon the internal metallic surfaces. This fact will explain why not only water tube, but multi-fire tube boilers cannot be economically employed under the ordinary circumstances of steam generation. The consideration of deposit or scaling, as well as that of workmanship, imposes a limit to the subdivision of heating surface amongst a great number of small tubes. In ordinary boiler making the geometrical advantage of the sphere cannot be turned to account. It cannot be produced economically in plate-iron, nor, if made in plate-iron, could it be advantageously applied in a steam boiler. The hollow sphere has this property, to wit: with a given thickness of metal it has twice the strength of a hollow cylinder of the same diameter. This is upon the assumption (which is correct where the cylinder is of a length greater than its own diameter) that the ends of the cylinder offer no resistance to a bursting pressure exerted against the circumference. Under overpressure, a closed cylinder would take the shape of a barrel, and if of

homogeneous material and structure it would burst at the middle of its length, and in the direction of the circumference. The circumference of a sphere of a diameter of 1 being always 3·14159, the sum of the length of the two sides of a cylinder of the same diameter, and having a plane of rupture of the same area, is 1·5708, or exactly half as much. And not only are the boiler-heads of no service in resisting the strain in the direction of the circumference of the cylinder, and not only are they weak in themselves, except when of a hemispherical form, or when well stayed, but furthermore, the whole pressure against them is exerted to produce a strain of the sides of the cylinder in the direction of its length, and where there are no through stay-rods between the opposite heads, this strain is necessarily equal to one-half of that exerted in the direction of the circumference.

The bursting pressure of steam boilers is commonly calculated from the average tensile strength of wrought iron plates. This strength is very variable, however, and it would be more logical to take the minimum. The most extensive series of experiments upon the strength of iron plates is that made by Mr. Kirkaldy for Messrs. Napier, of Glasgow. The number of samples of each description of iron tested was not large yet the tensile strength ranged between very wide limits. That of Yorkshire iron varied between 62,544 lbs per square inch and 40,541 lbs, both specimens being from the same makers. Staffordshire plates varied between 60,985 lbs, and 35,007 lbs, and Lanarkshire plates between 57,659 lbs and 32,450 lbs. The conclusion cannot be resisted that engineers are frequently dealing with boiler plates of a tensile strength not greater than from 16 tons to 18 tons per square inch, notwithstanding that the average strength may be 22 tons, and the maximum 27 tons. And the loss of this strength in punching the rivet holes is not merely that of the iron cut out, but the punch is found to sensibly injure that which remains. Mr. Fairbairn's well known and frequently verified ratio of 56 to 100, as the strength of a single riveted joint to that of the unpunched plate, must be always admitted in calculations of the strength of riveted boilers. The 40-horse Lancashire boiler, 7 ft. in diameter, will thus be often found to have an ultimate strength not greater, when new, than that corresponding to a pressure of from 210 lbs to 235 lbs per square inch. This, however, is without taking account of the strain exerted longitudinally upon the shell of the boiler by the pressure on the ends, and it is upon the assumption, which is hardly tenable, that the boiler heads, and especially the flues, are of the same strength as the cylindrical body or shell. Without the angle iron strengthening recommended by Mr. Fairbairn, the collapsing pressure of the flues of large boilers was found, in that gentleman's experiments, to be sometimes as little as 87 lbs per square inch. The strain resulting from the circumferential and longitudinal components, in the outer shell, is one-eighth greater than that calculable for the circumference alone, so that, even if the heads and flues were stayed to the strength of the shell, this would correspond to a pressure of but from 190 lbs to 210 lbs instead of 210 lbs to 225 lbs, as just supposed. But these estimates are for

the strength of the boiler when new. In the experience of the officers of the Manchester Boiler Association, with from 1300 to 1600 boilers always under their care, one boiler out of every seven, and, in some years, as in 1862, nearly one of every four, became defective by corrosion alone, while of every eight boilers examined in the course of a year, seven are found to be defective in some respects. Thus, in 1862, with 1376 boilers under inspection, 85 positively dangerous, and 987 objectionable defects, were discovered, 37 dangerous and 270 objectionable cases of corrosion alone having been reported. As a boiler malady, corrosion corresponds in its comparative frequency and fatality to the great destroyer of human life—consumption. It is the one great disease. It is frequently internal in consequence of the presence of acid in the water; but it is still oftener external, and it is most insidious and certain wherever there is the least leakage of steam into the brick-work setting. Condensed steam, or distilled water is an active solvent of iron, as well as of lead; and peaty water, which, so far as *inorganic* matter is concerned, is very pure, and distilled water from surface condensers, and indeed any water that is quite soft, is known to eat rapidly into the substance of the boiler in which it is used. A trickling, however slight, of condensed steam, down the outside of a boiler, will infallibly cause corrosion, and to this was directly traced a large number of the forty-seven boiler explosions which occurred in the United Kingdom, in 1863, and which were attended with the loss of seventy-six lives, besides injuries more or less serious to eighty persons.

Corrosion is most rapid where the iron is comparatively pure, as in the best Yorkshire and Staffordshire plates. The presence, however, of a small proportion of carbon, as in steel, or especially of silica and carbon, as in cast iron, renders it nearly indestructible. The experience even with cooking utensils demonstrates this, but it is more satisfactory to observe the fact in engineering operations on the great scale. When Nelson first introduced the hot blast, he employed wrought iron heating stoves, and although only 300° Fahr. was at first fixed upon for the temperature of the blast, the stoves were rapidly destroyed. It need hardly be mentioned that a wrought iron gas retort would be worthless, where cast iron answers well, being inferior only to fire-clay. It is the same with forge tuyeres, cast iron lasting indefinitely. Since superheated steam began to be generally employed, much difficulty has been experienced from the rapid corrosion of the superheaters. The Peninsular and Oriental Company's engineers have been compelled to adopt copper, instead of plate iron, heating surfaces for this purpose. Messrs. Richardson and Sons, of Hartlepool, have on the other hand adopted cast iron, and their superheaters of this material show no corrosion whatever after four years use. The sulphurous fumes from locomotive engines rapidly corrode the plate iron station roofs, while the cast iron girders and cornices remain unaffected. Cast iron bridges are indestructible by rusting, while large quantities of iron scales are being removed from wrought iron bridges, including the Conway and Britannia tubes. From abundant experience with cast iron

steam boilers and the tubes of cast iron heating apparatus, it may be taken as settled that, where the thickness is moderate, cast iron may be thus employed without the possibility of corrosion.

The tensile strength of cast iron varies between 5 tons and 15 tons per square inch. Considered as a material for boilers only the minimum strength should be regarded, exactly as from 16 tons to 18 tons has been taken for wrought iron plates. Cast iron boilers 8 feet in diameter, and of great length, were at one time made, but these were manifestly objectionable. The spherical form, of moderate diameter, is preferable, and whatever is the bursting strength of a riveted wrought iron cylinder, that of a cast iron sphere of the same diameter and the same thickness of metal will be the same. The plate iron of a strength of 18 tons per square inch, is virtually weakened to 10 tons by the loss in riveting, and as the hollow sphere is twice stronger than the hollow cylinder of the same diameter and thickness, the cast iron, having no joints, becomes equal in this comparison, to the wrought plate. If we could always count upon the maximum strength of iron, to wit, 27 tons per square inch for wrought, and 15 tons for cast, a 14-foot cast iron sphere would have the same strength to resist bursting as the 7-foot cylinder of the Lancashire 40-horse boiler, supposing the same thickness of metal in each case. But there is no occasion to make a boiler a single large sphere, for it is now ascertained from extensive experience that hollow cast iron spheres of small diameter do not retain the solid matter deposited by the water. Small water tubes, and, indeed, all small water spaces in ordinary boilers, always choke with deposit when the feed water contains lime, but cast iron boiler spheres although they may be temporarily coated internally with scale, are found to part with this whenever they are emptied of water. This fact is the most striking discovery that has been made in boiler engineering. It removes the fatal defect of small subdivided water spaces, which can now be employed with the certainty of their remaining constantly clear of deposit. This discovery has been made in the use of the cast iron boiler invented by Mr. Harrison, of Philadelphia, U. S., and which is now working in several of the Midland and Northern counties. Mr. Harrison employs any required number of cast iron hollow spheres, 8 inches in external diameter, and $\frac{3}{8}$-inch thick, these communicating with each other through open necks, and being held together by internal tie-bolts. A number of these spheres are arranged in the form of a rectangular slab, and several of these slabs, set side by side and connected together, form the boiler, about two-thirds of the whole number of spheres being filled with water, while the remainder serve as steam room. The bursting strength of these spheres corresponds to a pressure of upwards of 1500 lbs per square inch, as verified by repeated experiment, being, therefore, from six to seven times greater than that of the ordinary Lancashire boilers of large size. The evaporative power, as in all other boilers, depends upon the extent and ratio of the grate area and heating surface, but in practice from $7\frac{1}{2}$ lbs to 8 lbs of water are evaporated per pound of coal in a cast iron boiler, which, for each ton of its own weight, sup-

plies steam equal to 10 indicated horse power. The joints between the spheres are made by special machinery, securing the utmost accuracy of fitting, and there is no leakage, either of water or steam. The spheres occupied as steam space are screened by fire-bricks from the direct action of the heat, but enough is allowed to reach them to secure complete drying, and, if desired, any degree of superheating of the steam. The slabs, into which each series of spheres is assembled, are placed in an inclined position, which secures the thorough circulation of the water. The whole quantity of water carried in a 40-horse boiler is 3 tons, the boiler weighing 13 tons, and presenting 1000 square feet of water heating, and 500 square feet of steam drying surface. In Manchester, with the feed water taken from the Irwell, or from the canal, a hard scale is soon formed in the ordinary boilers; but in the cast iron boiler a succession of thin scales of extreme hardness are found to form upon, and to become detached of themselves from the inner surfaces of the water spheres. These scales are blown out with the water at the end of the week, and only small quantities can be discovered when purposely sought for. A specimen of these, slightly cohered together into a friable mass, is exhibited. A pint of loose scales and dirt is the most that has yet been found on a careful internal examination after nine months daily work. None of the iron is removed with the scale; the weight of the spheres, after three years service, being the same as when new. In America, Mr. Harrison's cast iron boiler has been worked for six years. Messrs. Denton, chemists, of Bow-common, London, have had one in use for three years, and for the last two years the same description of boilers have been employed at Messrs. Hetherington's and other large works in Manchester. It should be added that the system of casting the spheres is such that their thickness is necessarily the same at all points.

The self-scaling action, which has been found to be the same in all cases where the boiler has been worked, can only be explained by conjectures, which it is not, perhaps, necessary to introduce into the present paper. It deserves the careful investigation of the chemist and mechanical philosopher, with whom the author prefers to leave the subject.

Recent Experiments on Artificial Stone, &c.

From the Lond. Civil Eng. and Arch. Jour., August, 1864.

The following is extracted from the report of the committee appointed by the council of the Royal Institute of British Architects, 2d March, 1863, for the purpose of making experiments on artificial stone.

This Committee met on the 11th of March, 1863, and at once issued notices, and advertised in the public journals, that it was desirous of receiving prospectuses or other information connected with the manufacture of Artificial Stone; and resolved—

That each patentee be informed that this Committee proposes to report merely on the actual facts which may appear in the investigation;

That, so far as possible, the various materials used in the investigations be supplied under the immediate supervision of this Committee;

That Mr. C. H. Smith, Honorary Member, be added to this Committee;

That some eminent Chemist be associated with this Committee, in order to assist it in the investigation of the processes [Mr. Alfred White was thereon added]; and

That each patentee be requested to inform this Committee of the proceedings he would propose to adopt with regard to the investigation of his process.

It received responses from Messrs. Coignet, Ransome, Bodmer,* and Wheeble.†

Mr. Charles M. Westmacott put forward his patent cement and plaster; and they, although perhaps beyond the scope of the Committee, were received by it, on account of the interest that had been shown in the patent at the meeting of the Institute on the 23d of February, 1863.

The Committee met eleven times at Mr. Dines's, Grosvenor-road, twice at Mr. Tracey's, and once at Mr. Ransome's, in Cannon-row, exclusive of a visit to his works at Ipswich on the 15th of December last.

On the first meeting at Mr. Dines's, the Committee met Mons. Coignet for two successive days, (7th and 8th of April, 1863,) who prepared before it various blocks of his patent beton, which were experimented upon at future meetings. The Committee having had regard to the state of materials after exposure to atmospheric influences, and the reverse, the results in these as in all its other experiments may be taken as certified by the extreme care that it has taken, and are herewith appended in tabular forms.

The Committee met in Cannon-row on the 15th of May, 1863, and Mr. Ransome thoroughly explained, in the most open and satisfactory manner, his process; but as he stated that he could not, on so small a scale of manufacture, and without machinery, provide fair samples, it permitted him to prepare (from moulds supplied) samples at his works at Ipswich, and to forward them to London, guaranteed by him, to be experimented upon before it. The Committee, however, not being satisfied with the results, thought it advisable to see samples made, and intimated its wish to Mr. Ransome, who most liberally received it at Ipswich on the 15th of December last, and exhibited his mode of manufacture on a large scale. Specimens from the moulds supplied by the Committee were made before it, which were tested in like manner.

The Committee deemed it advisable, for the better understanding of the results obtained, to institute experiments upon other materials as a means of comparison, the results of which are appended in Tables D, E, and F; and it would particularly direct attention to Table D, showing a series of experiments suggested by Mr. John W. Papworth, on cubes of Portland stone, 2″, 4″, and 6″ in height, by their respective beds, cut from a carefully selected block 2′ cube. The deductions to be drawn from this table appear to be, that the results obtained

* Patent Stone Bricks. † Reading Abbey Stone.

from crushing small cubes of 2″ and under on the side, as usually given in accepted tables, must be received with considerable caution, inasmuch as while 2″ Prisms 2″ × 2″ bore 1·5 of a ton put on the square inch, and 2″ Prisms 4″ × 4″, and 2″ Prisms 6″ × 6″, nearly 2·5 tons, yet 6″ Prisms 6″ × 6″ and 4″ Prisms 4″ × 4″, only bore 1·9 of a ton on the square inch, showing that the strength certainly increased with the size of the area, but apparently not in any definite proportion; while it was observed in these experiments that the height had considerable influence upon the ultimate resistance, a result not expected, and in contradiction of the usual neglect of the height, until that element exceeds six times the diameter.

From Table F, it appears that the cohesive power of cements may be classed in the following order:—Martin's, Portland, and Roman; but it must be borne in mind that none of these had been exposed to atmospheric influences; yet the very remarkable differences without any appreciable cause in the results of the various experiments shows that the strength of cements is a subject upon which no satisfactory theory has yet been definitely propounded.

The Committee trusts that the time required for preparing and testing, at given intervals, so many and various materials, will be sufficient reason for not laying the Report earlier before you; and it will be seen from the extreme variation in the results given by the experiments, that the Committee is justified in repeating the experience of all zealous investigators—viz: that, without regard to the well-known inapplicability of general formulas to particular works, the council must not be surprised at finding that the Committee will not draw peremptory deductions from even the experiments made, considering that the least number, to arrive at anything like a perfect conclusion, should be more than twenty of each size of every material: the Committee felt that it had no right to exact so much time and expense as thereby would be required from the professional gentlemen of your Committee, or from Mr. Dines, who personally superintended the details of each experiment; and, moreover, it had no funds placed in its hands by the Council for that purpose.

The Committee feels anxious to express its sense of the liberal and zealous manner in which Mr. Dines put the resources of his establishment, and his own time at its disposal, furnished the samples and materials from which most of these experiments were made, and suggested the form which it believes to be quite novel of moulds for those to prove by tensile strength the cohesive power. The Committee otherwise could not possibly have carried out the experiments to the extent which, however incomplete, has furnished, it believes, as far as they go, a very trustworthy parallel of the strength of materials, deduced from specimens of a larger size—viz: 4″ cubes—than has generally been adopted.

Table showing Strength under Pressure of different Materials.

4-INCH CUBES.

MATERIALS.	Cracked.	Crushed.	on sq. inch.	REMARKS.
STONE.				
Portland.	Tons.	Tons.	Tons.	
Brown Top Bed.	. .	26·7	1·66	went at once :
" "	19·8	23 0	1·43	at ⌊ to bed.
" "	17·8	19 0	1·18	at ⌊ to bed.
" "	16 7	17 5	1·09	
" "	14·1	16 2	1·12	at ⌊ to bed.
" "	. .	15 8	0·99	went at once shelly.
" "	7·5	12·2	0 76	split both horz. & perp
" "	10·6	11·5	0·70	
Base or Best Bed.	32·6	36·2	2·25	split horizontally.
" "	13·5	28·0	1 75	
" "	26·4	27 0	1·68	
" "	18·0	20·1	1·25	on bed.
" "	16·4	16 5	1·31	"
" "	11·4	14·4	0·90	⌊ to bed.
" "	13·3	13·4	0·83	"
Mansfield.				
Red	39·0 *a*	40·1	2·5	*a* at 28 0
"	49·7	68 8	4·3	scaled off in small pieces. both very fetid.
White	21·5	36·4	2·27	scaled at 21·5
"	12·0	24·0	1·5	
Forest of Dean.				
White	17·5 †	47 8	2·98	† slight crack external only
"	43·0	45·0 *	2·81	* not considered very best.
"	30·0	40·0	2 5	all broke suddenly like iron
"	38·0	39·4	2·46	
Bath.				
Corsham . .	8·0	8 84	·55	
" . .	. .	8 3	·51	crushed suddenly.
" . .	7·5	8·1	·51	
Box Best Bed.	. .	5·4	·32	
" Ground, "	. .	8·6	·53	
" " " . .	5·7	5 85	·36	broke at once into 4 cones
" " " . .	. .	4·35	·32	
Caen.	8 2	15·4	·93	
. . . .	7·5	12·7	·79	
Gypsum.				
Derbysh. Alabaster.	10·9	11·0	·72	
Marble.				
Cornwall Serpentine				
" Poltesco Green	25·0	52 0	. .	at 15·4 slightly, at 40· going fast, smashed.
" Signal Staff }	10·0	51·0	3·2	smashed.
" Blk. & Rd. }				
" " "	10·50	37·75	2 35	

Table Continued.—4-INCH CUBES.

MATERIALS.	Cracked.	Crushed.	on sq. inch.	REMARKS.
SLATE.	Tons.	Tons.	Tons.	
North Wales.				
Machynlleth . .	. .	83·5 *a*	5 21	*a* at 71 splinter flew off
Bangor (Penryhn)	. .	80·0 *b*	5·0	*b* no effect, neither b'k
Portmadoc—				
Welsh Slate Com.	20·6	75·3	4·70	
Festiniog ditto.	20 0	70·5	4·40	
. . . . .	. .	63·0	3·93	
Maenoffern	23·6	65·4	4·08	4·86 average.
Pen-Machno, Conway,	. .	48·8	3·05	
Dinorwic, Llanberis	. .	49·0	3·06	
Cornwall.				
Delabole . .	52·0	61.6	3·85	broke at ⌊ to bed.
Ireland.				
Valencia.	. .	57·3	3·58	
WOOD.				
Teak, Moulmein . .	. .	50·8	3·17	crushed endways.
Deal, Archangel . .	. .	28·8	1·11	" fibres torn apart.
CONCRETE.				
1 Lime 3 Ballast	. .	5·1	·31	3 weeks old.
1 Slk. Lime 3 ballast	. .	5·2	·32	
MARTIN'S CEMENT.	. .	14·85	·92	22 hours old.
PLASTER, Common.	. .	4·95	·30	22 hours old.

9-INCH BRICKS.

MATERIALS.	Cracked.	Crushed.	on sq. inch.	REMARKS.
	Tons.	Tons.	Tons.	
Common Stocks . .	. .	30·0	·7407	
" " . .	. .	18·0	·4432	
" " . .	. .	12·0	·2962	
" ground sides	22·5	26·8	·6616	
" " "	. .	31·5	·7777	
Burham Brick . .	59·8	73·6	1·817	
" " . .	. .	80·0*a*	1 985	*a* Not crushed.
" " . .	. .	62·0*b*	1·340	*b* Cracked slightly, not crushed.
Place, bad . .	8·4	9·0	·2222	
"	8·0	10·7	·2641	
Grizzle	. .	14·0	·3456	

Table Continued.—9-INCH BRICKS.

MATERIALS.	Cracked.	Crushed.	on sq. inch.	REMARKS.
Stocks.				
2 joined in Mortar	5·0	8·7	·1071	
† " " in Cement	7·0*	15·35*	·1896	*Small pieces flew off at intervals, but cement stood.
Place.				
2 joined in Mortar	. .	5·3	·0641	†About 14 days old.
† " " in Cement	. .	9·4	·1160	

SHAFTS, 12 inches long, 3 inches diameter.

MATERIALS.	Cracked.	Crushed.	on sq. inch.	REMARKS.
STONE.	Tons.	Tons.	Tons.	*All yielded vertically.*
Portland, worked · ·	7·3	10·25	1·48	bedded in leather.
" rgh. tooled	. .	8·57	1·00	" in plaster.
Marbles (Devonshire.)				
Ippleen, Mottled red,	9·2	10·7	1·37	
Poltesco, grey-green,	4·3	4·3	·60	went across and not with
" "	. .	6·0	·84	went at once. [vein
Signal-Staff, red & blk,	. .	33·5	4·73	went in fragments.
" "	20 0	22·5	3·18	" "
" "	12·75	16·25	2·29	
Cadgewith, grn. & blk	16·92	17·62	2·49	
WOOD.				
Deal, Archangel · ·	. .	19·1*a*	2·70	*a* lost 3-16ths in length:
6″of above sawn off left	. .	19·3	2·73	point of yielding 5·12ths
Deal, Archangel · ·	. .	16·3*a*	2·30	of length in both.
6″of above sawn off left	. .	19·4	2·74	
Teak, Moulmein · ·	. .	18 25*b*	2 58	*b* lost 1-8th and point of
6″of above sawn off left	. .	18·7	2·64	yielding about same.
Teak, Moulmein · ·	. .	16·0*b*	2 26	
6″of above sawn off left	. .	17·75	2·50	

The Committee then proceed to state, that having regard to the difficulty of drawing inferences from a long series of tables, and the desirability of general statements of results, they have, at considerable labor to themselves, prepared such statements. Of these the following are the chief:—

Mons. Coignet's process is admitted to be highly successful on a large scale in Paris; but the majority of the cubes prepared by him do not appear to be much stronger under pressure than ordinary concrete, and inferior to Bath stone, although they improve by age; and this weakness is impugned by him as a result on the ground that the samples were made out of his factory, and that he had not all the appliances requisite at command. A step-landing, and bas-relief, made, in April, 1863, from the sweepings of refuse used for making blocks for experiments, are still at Mr. Dines's, and having been exposed to the weather, as well as to wear and tear, appear to stand as well as Portland cement.

Mr. Ransome's process, the Committee states, appears to be founded on scientific principles, and theoretically ought to answer. It was, however, found that there must be some difficulty in insuring the complete combination of the ingredients, and that few of the specimens especially prepared for the Committee were thoroughly successful in that respect, and but few of those made in its presence. There is an important difference between these and Mons. Coignet's examples, that Mr. Ransome is not able to declare that his process is highly successful on a large scale, but represents that he has not yet completed the appliances to put it into operation. In some of his specimens there appears an improvement as they advance in age; but so irregular is this that no reliance can be placed upon that feature. But it would seem that, if the process of penetration is complete, the ultimate strength is attained in a short period, and that the external influences of weather had little effect upon them in that respect. The Committee feels that if Mr. Ransome can insure the perfection of his entire process, restrict himself to the production of work for each occasion, as it may arise, and (for the sake of artistic excellence) avoid becoming a manufacturer of casts from a certain number of moulds, it is possible that for external decorative purposes there is a large field open to him; but they are of opinion that, as yet, Mr. Ransome has not rendered his material suitable for the chisel of the carver or the tool of the modeler.

Mr. Wheeble (Reading Abbey Concrete Stone) sent moulded bricks, made at Reading, from the works to the Committee, and they seem to have an ultimate strength, apparently produced by the use of stone lime from Bridgewater, equal to that of common stocks; the latter however possess the advantage of not yielding until the instant of disintegration. The 4″ cubes made in moulds supplied by the Committee, and in its presence, never attained the strength of concrete except in a case where large gravel or flint was the chief ingredient.

Messrs. Bodmer (Patent Compressed Stone Bricks) expressed their inability to comply with the requisitions of the Committee as to 4″ cubes, as the moulds of their press were of ordinary brick size; and if their material were pressed by manual labor into 4″ cube moulds it would not represent the artificial stone which they were in the habit of producing. The Committee accepted accordingly bricks supplied from their works, which show a steady progressive increase in strength as they advance in age; and the results justify the statement made by Messrs. Bodmer, that after six weeks to two months the bricks are fit for use. The Committee regrets the unfortunate inability of Mr. Charles Westmacott to put himself satisfactorily in connexion with persons having at their disposal the premises and materials which he required for the display of the qualities of his processes. These chiefly depend upon the mixture of natural materials before adding water. The Committee has been able, however to test one or two experiments, which result in giving it a favorable opinion of the system adopted by him both for ceilings and for composition applied internally or externally. These may still be seen in Mr. Dines's yard, having been

exposed through last autumn and winter. The quick stucco, for rendering ceilings, was tried in the month of May, 1863, consisting of unslacked lime, chalk, and sand, mixed pure, before adding water; it occupied in making and setting twenty minutes, was followed within an hour by ordinary gauged stuff, and stood without cracking. Messrs. Francis, of Nine Elms, have recently made arrangements with Mr. Westmacott to apply his processes practically; from their operations, on a more extended scale than was possible to be carried on before the Committee, the valuable character of his invention may be more decidedly proved.

Had the results of the experiments now laid before you been more consistent with each other, and had they resulted in conclusions highly favorable to the various processes, the Committee would still have felt bound to impress upon the members of the profession who have the opportunity of trying novelties, that future experiments for testing the strength of materials should be made on cubes of larger dimensions than have been heretofore employed; and they would suggest that cubes of 6″ sides would perhaps be the simplest and best adapted for the purpose: with regard to time, years instead of months are necessary to enable any one to arrive at practical conclusions as to the durability of any artificial material put forth in lieu of natural ones.

From among the tables appended we select the two given, in preference to those which tabulate the results of experiments on artificial materials, principally on the ground that experiments with the latter must be regarded as not yet furnishing results of permanent value, owing to the constant changes and improvements still being introduced.

Table showing the results under pressure of Cubes 2″, 4″, and 6″ in height, by their Base.

PORTLAND STONE (*Brown Bed.*)

HEIGHT.	Base.	Cracked.	Crushed.	on sq. inch.	REMARKS.
	″ ″	Tons.	Tons.	Tons.	
2″	2 × 2	. .	3·2	0·8	At once.
"	2 × 2	4·0	6·0	1·5	
"	4 × 2	. .	20·2	2·5	At once.
"	2 × 6	21·0	23·5	1·70	
"	4 × 4	8·0	41·0	2·5	Across the bed.
"	6 × 6	64·0	86·0	2·4	
4″	2 × 2	. .	3·0	0·75	
"	4 × 2	. .	17·0	2·12	
"	4 × 4	25·75	29·25	1·82	
"	4 × 4	24·25	28·75	1·85	
"	4 × 6	31·0	45·0	1·87	*a* Very slight external.
"	6 × 6	48·0*a*	82·0*b*	2·27	*b* Not crushed.
6″	2 × 2	2·8	3·4	0·85	
"	6 × 2	. .	10·0	0·83	
"	4 × 4	18·0	20·45	1·27	⊥ to bed.
"	6 × 4	28·0	32·0	1·33	
"	6 × 6	64·0*c*	70·0	1·94	*c* Very slight.
"	6 × 6	55·0	68.75	1 90	

For the Journal of the Franklin Institute.

General Problem of Trussed Girders. By De Volson Wood, Prof. of C. E., University of Michigan.

(Continued from page 311.)

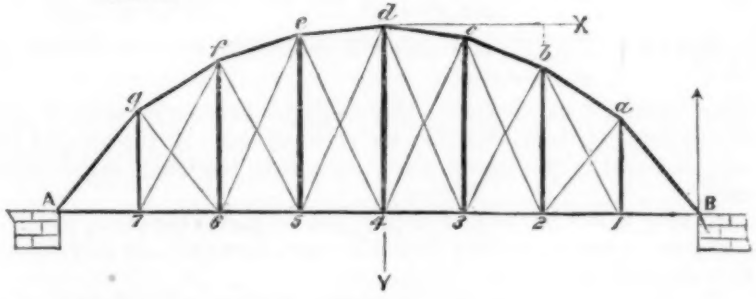
The formulas which express the strains upon the several parts of trusses which are in common use, should be as simple as possible, and when possible should be continuous functions of the strain and distance from some fixed point, as one end for instance. This can generally be done when the curve of the chord follows an algebraic law.

We will suppose that the bays on the lower chord are all equal to each other, and that the load consists of equal weights placed at the upper or lower joints. If these hypotheses do not correspond with any practical case resort may be had to the equations already given.

14°. *Let the lower chord be horizontal and the upper one parabolic, or, if polygonal, let the vertices of the polygon be in a parabolic arc.*

Some parts of this problem were very fully discussed in my article on the "*Trussed Arch*," found in the April number of this *Journal* for this year, on page 223. I shall therefore notice it very briefly here, merely showing how to apply equations (20) to this case.

FIG. 11.



Let Fig. 11, represent the truss.

Let N = total number of bays in the horizontal tie,

n = the number of the bay considered, counting from either end,

D = $d4$ = greatest depth of the truss,

l = length of a bay = 1—2 = 2—3, &c.,

p = one of the equal weights which constitute the load,

W = the total load when uniformly distributed over the span; and the other notation the same as before given.

Then $p = \frac{W}{N}$.

We first suppose that the bridge is uniformly loaded throughout

with equal weights placed at the joints 1, 2, 3, &c. Then we readily find $V = \frac{1}{2}(N-1)p$, $\Sigma_0^x P = (n-1)p$; $x_1 = nl$ . . (26)

and $h = \frac{4D}{N^2}(N-n)n$, $\Sigma_0^x Px = \frac{1}{2}n(n-1)pl$.

These substituted in the third of equations (20), and reduced will give

$$H_1 = \frac{plN^2}{8D} \quad . \quad . \quad . \quad . \quad (27)$$

Equation (27) being independent of n, shows that the strain on the horizontal tie is constant throughout.

I find that the simplest forms for the values of F and F_2, are found by eliminating among equations (20) and placing the results in the following form:

$$F_2 \cos\theta = \frac{V - \Sigma_0^x P - H_1 \tan i}{1 - \tan\theta \tan i} \quad . \quad . \quad (28)$$

$$F \sin i = \frac{V - \Sigma_0^x P - H_1 \cot i}{\cot\theta \cot i - 1} \quad . \quad . \quad (29)$$

In the article referred to above it was shown [equations (13*a*) and (14)] that,

$$\tan\theta = \frac{lN^2}{4Dn(N-n)}, \text{ and } \tan i = \frac{4D}{lN^2}(N-2n+1) \quad (30)$$

Equations (26), (27) and (30) will reduce (28) to

$$F_2 \cos\theta = 0;$$

hence there is no strain on the diagonal ties for an uniform load throughout. It is evident that the strain on each of the vertical ties is p, and that they transmit the strains from the lower chord to the arch.

Making $F_2 = 0$ in the first of (20) and we have $F \cos i = H_1$ which is a simpler equation, for this particular case, than (29). It corresponds with the first of (16).

This discussion shows that to produce strains on the diagonal bars it is necessary to load the bridge over only a part of its length, or else unequally load the joints.

If the diagonal bars act as ties, and the bridge be loaded for maximum shearing, we have for the strains on the n^{th} tie, [see equation (17), page 229 of the April number],

$$F_2 \cos\theta = \frac{(N-n+1)(n-1)}{2N} p \quad . \quad . \quad (31)$$

If the diagonal ties sustain the load which is at their lower ends, we must add p to the above expression.

Let $n-1 = n^1$ $\quad \therefore -n+1 = -n^1$ and (31) becomes

$$F_2 \cos\theta = \frac{(N-n^1)n^1}{2N} p \quad . \quad . \quad . \quad (31')$$

which is the *form* taken by the equation when the bars act as braces. (See eq. 15, p. 228 in the April No.)

Equation (31') shows that *the strains vary as the product of the segments into which the span is divided by the vertical bar which passes through the upper end of the inclined tie.*

It is easy to show that the strain on the horizontal chord is greatest when the bridge is completely loaded; hence, for an uniform load we have for the greatest stress on this chord

$$H_1 = \frac{plN^2}{8D}, \text{ as given in equation (27).}$$

Similarly, the greatest strain on the arch is for a full load; and if the load be uniform, we have

$$F \cos i = H_1 = \frac{plN^2}{8D} \quad . \quad . \quad . \quad (32)$$

as given above.

From (30) we may find

$$\cos i = \frac{lN^2}{\sqrt{l^2N^4 + 16D^2(N-2n+1)^2}}, \quad . \quad (33)$$

which reduces (32) to

$$F = \frac{p}{8D}\sqrt{l^2N^2 + 16D^2(N-2n+1)^2} \quad . \quad (34)$$

From (30) we may also find that

$$\frac{1}{\cos\theta} = \frac{\sqrt{16D^2N^2(N-n)^2 + l^2N^2}}{4Dn(N-n)}$$

which reduces (31) to

$$F_2 = \frac{(N-n+1)(n-1)\sqrt{16D^2N^2(N-n)^2 + l^2N^2}}{8DNn(N-n)}p \quad (35)$$

Equations (27), (34) and (35) are necessary and sufficient for solving the problem.

Before leaving this problem it will be well to observe that for a load uniformly distributed over the whole length $V = \frac{1}{2}W = \frac{1}{2}Np$. But in this case only one-half the load on each of the end panels causes strains on the truss, because said half is sustained directly by the abutments, or supports. Making this deduction and we have for the re-action which causes strains $V = \frac{1}{2}(N-1)p$ as given in equation (26).

In order to bring together, in this connexion, all the equations for computing the strains on this truss, I copy the following from the article above referred to.

For maximum shearing in the panel system when the load is on the *upper* chord, we have

$$F_2 \cos i = \frac{(N-n)n}{2N}p \quad . \quad . \quad (36)$$

For maximum strain on the upper and lower chords use equations (27) and (32).

In the *Triangular System*, for maximum shearing, when the load is on the upper chord, we have

$$F_2 \cos\theta = \frac{(N-n)^2}{2N}\left[\frac{4n^2-1}{4nN-4n^2-1}\right]p, \quad . \quad (37)$$

with the load on the lower chord, we have

$$F_2 \cos\theta = \frac{(N-n)(N-n+1)}{2N}\left[\frac{4n^2-1}{4nN-4n^2-1}\right]p \quad (38)$$

$$\tan\theta = \frac{lN^2}{2D[N^2-(N-2n-1)^2]} \quad . \quad . \quad (39)$$

Equations (27) and (32) may also be used for this system, for finding the strains on the chords.

15°. *Let both chords be horizontal.*

For this make $i=0$ in equations (20) and they become,

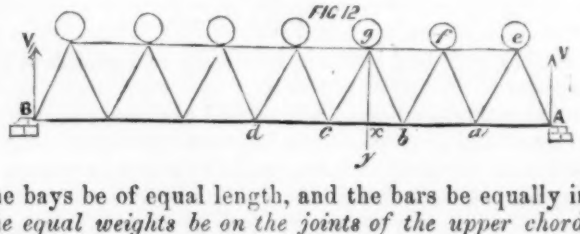
$$\left.\begin{aligned} H + F_2 \sin\theta &= H_1 \\ F_2 \cos\theta &= V - \Sigma_0^x P \\ HD &= Vx_1 - \Sigma_0^x Px \end{aligned}\right\} \quad . \quad . \quad . \quad (40)$$

in which D is the total depth.

The second of these equations shows that the ties or braces, as the case may be, resist all the shearing stress.

For an uniform load $V=\frac{1}{2}wL$, and at the middle section $\Sigma_0^x P=\frac{1}{2}wL$, which in (40) gives $F_2=0$, which shows that no ties or braces are needed at the middle. But it will be shown hereafter, that if the uniform load consists of equal weights placed on the joints, there will, in some cases, be a strain on the middle braces.

LET US FIRST CONSIDER A SYSTEM OF TRIANGULAR TRUSSING—see Fig. 12.



Let the bays be of equal length, and the bars be equally inclined.

Let the equal weights be on the joints of the upper chord. Then the total load is Np. $\therefore V=\frac{1}{2}Np$.

Let a vertical section be made just at the left of g, and call bc the n^{th} bay counting from A; or to be more specific, let n be the number of bays between the end and the *foot* of the brace considered. Then we readily find for the section gx,

$$\Sigma_0^x P = np$$

$$x_1 = (n-\tfrac{1}{2})\,l$$

$$\Sigma_0^x Px = \tfrac{1}{2}n(n-1)\,pl.$$

These in (40) give,

$$\left.\begin{aligned} H + F_2 \sin\theta &= H_1 \\ F_2 \cos\theta &= \tfrac{1}{2} p\,(N - 2n) \\ H_1 D &= \tfrac{1}{4}\left[N\,(2n-1) - 2n\,(n-1)\right] pl \end{aligned}\right\} \quad (41)$$

We also find $\tan\theta = \dfrac{l}{2D}$; $\sin\theta = \dfrac{l}{\sqrt{4D^2+l^2}}$; $\cos\theta = \dfrac{2D}{\sqrt{4D^2+l^2}}$.

For the braces which incline the same way as $g\,c$, $\sin\theta$ will be negative; for all others it is positive.

If N is even, we have $n = \frac{1}{2}$ N for the middle braces, which in the second of (41) gives $F_2 = 0$; or there is no strain on the middle braces; but if N is odd, we shall have $n = \frac{1}{2}(N+1)$ or $= \frac{1}{2}(N-1)$ for the middle braces. These values in the second of (41) will give $F_2 \sin\theta = +\frac{1}{2} p$. For the end braces $n = 0$, which gives $F_2 \sin\theta = \frac{1}{2} Np = V$.

For maximum shearing let all the joints on the left of g be loaded and those on the right be unloaded. Then we readily find:

$$\text{the total load} = (N-n)\,p,$$

$$V = \frac{(N-n)^2}{2N} p,$$

$$\Sigma_o^x P = 0,$$

$$\Sigma_o^x P\,x = 0,$$

$$x_1 = (n-\tfrac{1}{2})\,l.$$

These substituted in (40) give,

$$\left.\begin{aligned} H + F_2 \sin\theta &= H_1 \\ F_2 \cos\theta &= \frac{(N-n)^2}{2N} p \\ H\,D &= \frac{(N-n)^2}{4N}(2n-1)l \end{aligned}\right\} \quad . \quad . \quad (42)$$

But to combine the cases of uniform load throughout, and an uniform load to produce maximum shearing, we will suppose that the uniform load is the weight of the frame, and let $w_1 = W \div N =$ the weight of a bay in length of the frame. Then if $p = w_1$ in (41) those equations will give the strains, and by the aid of (42) we have for the strains,

$$\left.\begin{aligned} H + F_2 \sin\theta &= H_1 \\ F_2 \cos\theta &= \tfrac{1}{2} w_1\,(N-2n) + \frac{(N-n)^2}{2N} p \\ H_1 D &= \tfrac{1}{4} l\left[\left\{N\,(2n-1) - 2n\,(n-1)\right\} w_1 + \frac{(N-n)^2}{N}(2n-1)p\right] \end{aligned}\right\} \quad (43)$$

For an uniform load throughout including the weight of the frame we readily have from (41)

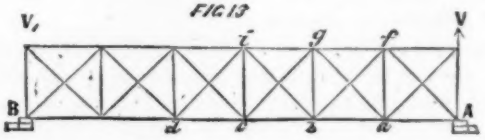
$$\left.\begin{aligned} H + F_2 \sin\theta &= H_1 \\ F_2 \cos\theta &= \tfrac{1}{2}\,(N-2n)\,(p+w_1) \\ H_1 D &= \frac{l}{4}\left[N\,(2n-1) - 2n\,(n-1)\right](p+w_1) \end{aligned}\right\} \quad . \quad (44)$$

The third of (44) is greater than the third of (43); hence, for the strains upon the chords we use equations (44). For n less than $\frac{1}{2}$ N, the second of (43) is greater than the second of (44); hence, we use the former to find the strains upon the braces.

Similar expressions might be found when the joints of the lower chord are loaded, but we will omit them and pass immediately to the

PANEL SYSTEM.

FIG 13



For a definition of this system see number 8° of this article. Let figure 13 represent the case. Many bridges have been made in this country upon this principle; among which I will mention the following:

Howe's Truss, in which the chords and inclined bars are made of wood, and the vertical ties are of iron, (See this *Journal* vol. iii. 3d series, p. 289, also, *Silliman's Journal* vol. xviii. p. 123): Pratt's Truss, in which the chords and vertical struts are of wood, and the inclined bars are iron ties, (see Vose's Hand-book of Engineering, p. 154): Long's Truss, which is composed entirely of wood, and the inclined bars are braces, (see this *Journal* vol. v, 2d series, p. 231.): Whipple's Truss, which is composed entirely of iron, and the inclined bars are ties, (see Appleton's Dictionary of Mechanics—the last edition—article Bridges,) and Jone's Truss, which is also made entirely of iron, (see *Scientific American* for 1863, vol. ix, p. 193.) These Trusses differ in the *details* of their construction and not in their mathematical properties, and as it is only the latter that we propose to discuss we shall not dwell upon their points of distinction. Many other trusses partake of some of the properties of those above mentioned.

We now proceed to discuss the theory. The strains upon the diagonal bars will be the same whether they act as ties or braces; also the strain upon them will be the same whether the load be on the upper or lower chord. But the strain on the vertical ties (or struts, as the case may be) is not the same for the load on either chord.

It may be seen from the second of (40) that the *vertical components* of the strains on the several braces which are between two consecutive weights, are equal to each other. For, V being constant, the first member will remain constant as long as Σ_0^x P is constant, and this is constant between two consecutive weights.

From this we see that when the load is on the lower chord, the *vertical components* of A f and $f\,a$ Fig. 13, will equal each other; so of $a\,g$ and $g\,b$. But if the load be on the upper chord, the vertical components of $f\,a$ and $a\,g$ equal each other; so of $g\,b$ and $b\,i$. If ties be used instead of braces, and the load be on the upper chord, then will the vertical components on $f\,b$ and $b\,g$ equal each other; but if the load

be on the lower chord, the vertical components on af and fb equal each other. If there be no load between c and A, the vertical components will be the same on all the bars between c and A.

Let n be the number of the panel counting from A, in which the strains are considered, which will be the same as the number of a brace (or tie) counting from the same end, and let the other notation be the same as given above.

Then for an uniform load in which the weight of the bridge is considered, we have

$$\begin{aligned} (\text{N}-1)\,(p+w_1) &= \text{the total load},\\ \text{V} &= \tfrac{1}{2}\,(\text{N}-1)\,(p+w_1),\\ \Sigma_0^{\,n}\theta\text{P} &= (n-1)\,(p+w_1),\\ x_1 &= n\,l \text{ for a section just at the right of } g,\\ \Sigma_0^{\,x}\ \text{P}\,x &= \tfrac{1}{2}\,n\,l\,(n-1)\,(p+w_1). \end{aligned}$$

These in (40), give

$$\left.\begin{aligned} \text{H}+\text{F}_2\sin\theta &= \text{H}_1\\ \text{F}_2\cos\theta &= \tfrac{1}{2}\,(\text{N}-2n+1)\,(p+w_1)\\ \text{H}_1\text{D} &= \tfrac{1}{2}\,(\text{N}-n)\,nl\,(p+w_1) \end{aligned}\right\} \quad . \qquad (45).$$

The third of these equations shows *that the strain on the lower chord varies as the product of the segment into which the span is divided by the vertical bar which passes through the upper end of the brace* (*or tie*) *which belongs to the panel considered.*

For maximum shearing there will be $(n-1)$ unloaded joints, and hence $(\text{N}-n)$ loaded joints, but still the weight of the frame must remain as an uniform load throughout. For this case we readily find, in the same way that we found equations (44) that,

$$\left.\begin{aligned} \text{H}+\text{F}_2\sin\theta &= \text{H}_1\\ \text{F}_2\cos\theta &= \tfrac{1}{2}\,(\text{N}-2n+1)\,w_1+\frac{(\text{N}-n)\,(\text{N}-n+1)}{2\,\text{N}}\,p\\ \text{H}_1\text{D} &= \frac{1}{2\text{N}}\left[(\text{N}-n)\left(\text{N}w_1+(\text{N}-n+1)p\right)\right]nl \end{aligned}\right\} \quad (46)$$

For n less than $\frac{1}{2}\text{N}$, the second of (45) is less than the second of (46); hence, we use the latter to compute the strains on the braces. For the strain on the chords use (45).

There is a point at which the shearing stress is zero; and it may be found by placing the second of (46) equal zero and solving for n. The general expression thus found is long and inconvenient, but it may be easily shown that there is one value between $\frac{1}{2}\text{N}$ and N—this we will call n_0. The other value exceeds N, and hence is inadmissible.

For example, if $p=w_1$, and $\text{N}=12$ we find $n_0=7{\cdot}9$

$p=2w_1$, and $\text{N}=10$ we find $n_0=6{\cdot}8$

In this way a table might be formed with the arguments p, w_1 and N.

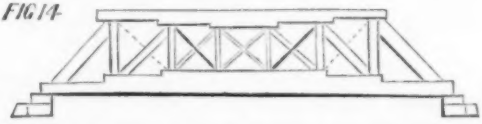
The second of (46) is positive for all values if n between 0 and n_0; and negative for all values between n_0 and N.

To show more clearly the force of this equation, let us suppose that the frame is loaded uniformly throughout, and that it moves off in the direction from A towards B. The strain on Af will be greatest when

all the load is on and is found by making $n=1$ in the second of (46); the strain on $a\,g$ is greatest when the rear end of the surcharge has reached a, and is found by making $n=2$ in the same equation: the strain on $b\,i$ is greatest when the rear end has reached b, and is found by making $n=3$; and so on to $n=n_{\circ}$, beyond which the expression becomes negative which shows that ties must be used instead of braces; or what is equivalent, the brace must be inclined the other way, like $d\,i$, for instance. The same phenomenon is observed if the load moves from B towards A. We observe that, counting from either end, the braces beyond $n_{\circ}$ incline in an opposite direction to those within that value. From 0 to $\frac{1}{2}$N, or $\frac{1}{2}$ (N + 1), the bars are usually called *main braces* or *main ties*; from $\frac{1}{2}$N to $n_{\circ}$, *counter braces*, because they incline in an opposite way from main braces.

Fig. 14 is a graphical representation of equations (46) and the principles which have here been developed.

FIG 14



We observe that the first term of the second member, of the second equation of (46) is positive, for n less than $\frac{1}{2}$ (N+1) and negative for n greater than that value, therefore, when the surcharge extends over half or more than half the bridge it conspires with the weight of the frame to produce strains upon the main braces; but they act against each other to produce the strains on the counter-braces. When there is a strain on a counter-brace, there is none on the main brace in the same panel. Between $n_{\circ}$ and N, the effect of the surcharge is merely to relieve the main braces of a portion of the strain which is produced by the weight of the frame alone.

For a queen post truss we have $N=3$, in (46);

$$\therefore \quad F_2 \cos\theta = (2-n)\,w_1 + \tfrac{1}{6}(3-n)(4-n)\,p,$$

and for the end brace or rafter make $n=1$,

$$\therefore \quad F_2 \cos\theta = w_1 + p.$$

For the braces in the middle panel, make $n=2$,

$$\therefore \quad F_2 \cos\theta = \tfrac{1}{3}\,p.$$

Braces are rarely put in the middle panel in the queen post truss, for the stiffness of the frame is relied upon to resist the concentrated load.

For single rafters make $N=2$, and $n=1$, in the second of (46);

$$\therefore \quad F_2 \cos\theta = \tfrac{1}{2}(w + p.)$$

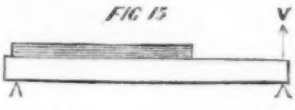
16°. The principles just stated are more forcibly illustrated by supposing that the ties are so near each other as to be considered continuous, and that the load is continuous and uniform.

For this, let x = the length of surcharge which is continuous from one end, see Fig. 15,
r = weight of surcharge on a unit of length,
L = length of frame,
w = weight of a unit of length of the frame.

Then $\quad V = \frac{1}{2}wL + \frac{rx^2}{2L}$

$$\Sigma_0^x P = w(L - x),$$

FIG 15



and the second of (40) becomes

$$F_2 \cos\theta = \tfrac{1}{2}w(2x - L) + \frac{rx^2}{2L} = y \text{ (say)} \quad . \quad (47)$$

This may be considered as the equation of a curve.

For $\quad x = 0\,;\ y = -\tfrac{1}{2}wL$

$$y = 0\,;\ x = \left(-\frac{w}{r} \pm \sqrt{\frac{w^2}{r^2} + \frac{w}{r}}\right)L \quad . \quad (48)$$

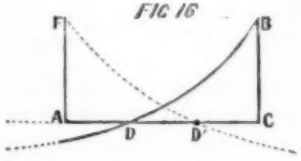
$$\frac{dy}{dx} = 0\,;\ x = -\frac{w}{r}.$$

Fig. 16 is a geometrical illustration of equation (47).

From (48) we see that the curve crosses at D, a point between A and the middle of the span. For instance,

if $\quad r = 10w\,;\ x = 0{\cdot}231L$
$\quad r = 5w\,;\ x = 0{\cdot}299L$
$\quad r = 2w\,;\ x = 0{\cdot}366L$
$\quad r = w\,;\ x = 0{\cdot}414L$
$\quad r = 0\,;\ x = \tfrac{1}{2}L.$ (See equation (47).

FIG 16



From C to D the braces incline from the support C, and from A to D, they incline from A. If the load moved in the opposite direction, the point of no shearing would be at D′, and between D and D′ braces must incline both ways to resist the strains arising from loads moving both ways.

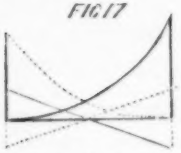
Equation (47) may be separated into two parts; one being the strains due to the permanent load; the other, to the surcharge. Call the former y_1; the latter y_2; and we have

$$y_1 = w(x - \tfrac{1}{2}L.) \quad . \quad . \quad . \quad . \quad (49)$$

$$y_2 = \frac{rx^2}{2L} \quad . \quad . \quad . \quad . \quad . \quad (50)$$

Equation (49) shows, that for an uniform load extending over the whole span, the strains increase uniformly from the middle towards the ends.

FIG 17



Equation (50) shows that they increase as the ordinates of a common parabola, counting from one end. The axis of the parabola is perpendicular to the span. Fig. 17, represents equations (49) and (50).

17°. It is desirable to have some easy mode of determining whether a bar is subjected to a thrust or pull. It is evident that the bars of the upper chord are all subjected to a thrust, while those in the lower chord are subjected to a pull or tension. But the inclined bars may be subjected to either, and in varying circumstances to both kinds of strain. To determine to which strain any bar is subjected under any given condition; we observe, first, that the shearing stress is $\left\{\begin{matrix}\text{positive or upwards}\\ \text{negative or downwards}\end{matrix}\right\}$ when the second members of (40), is $\left\{\begin{matrix}\text{positive}\\ \text{negative}\end{matrix}\right\}$. If we conceive the load to be divided by a vertical plane so that the part between A and the plane shall equal V, see fig. 12 or 13, then will the shearing stress between V and the plane, be positive; and beyond the plane it will be negative. Or, this principle may be stated thus: the shearing force will be $\left\{\begin{matrix}\text{positive}\\ \text{negative}\end{matrix}\right\}$ according as the plane section is $\left\{\begin{matrix}\text{nearer}\\ \text{more remote}\end{matrix}\right\}$ than a plane which divides the load into two parts respectively equal to the re-action of the supports.

We next observe that all the bars which are similarly situated on either side of the dividing plan will be subjected to like strains.

Finally, the brace *Ae* (fig. 12, or *Af* fig. 13) is subjected to compression, and its angle of inclination and the shearing stress are both positive; hence *we have this general principle; for ordinary trussed bridges:*

A bar is subjected to a $\left\{\begin{matrix}\textit{thrust}\\ \textit{pull}\end{matrix}\right\}$ *when the sign of its angle of inclination is* $\left\{\begin{matrix}\textit{the same as}\\ \textit{contrary to}\end{matrix}\right\}$ *the sign of the shearing stress on a plane section which passes through the bar.*

This rule which is essentially that given by Rankine for a similar case, (see his Applied Mechanics, p. 161) fails in many cases when applied to trusses of different form. For instance, in the double rafter, as shown in Fig. 18, the inclination of both the right hand rafters is *positive*, and the shearing stress is positive; yet the lower one is subjected to tension.

In Fig. 19, all the bars have a *positive* inclination, while the alternate ones are subjected to tension.

Tredgold in his Carpentry (Fourth edition p. 12) gives the following rule to distinguish ties from struts.

FIG 18

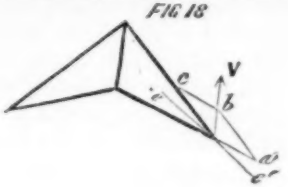
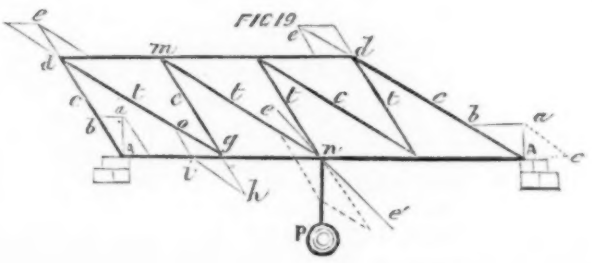


FIG 19



"Let a parallelogram be constructed on the direction of the straining force as a diagonal, the sides of the parallelogram being parallel to the sustaining forces; then, let the other diagonal of the parallelogram be drawn; and, parallel to it, draw a line through the point where the directions of the forces meet. Consider towards which side of this line the straining force would move if left at liberty; and all supports on that side will be in a state of compression and all those on the other side will be in a state of tension."

For instance, in Fig. 18, construct a parallelogram on A V as a diagonal, having its sides parallel to A B and A C. Draw $e\,e'$ through A parallel to $a\,c$. Now if V were free to move it would move vertically upward, and as A B is above $e\,e'$ it would, according to the rule, be compressed and A C extended. The rule draws a correct conclusion in this case; still it is not infallible. For if we suppose there is a single weight acting on the frame, as shown in Fig. 19, and we apply the rule to it, we will find that all the bars at the right which are marked *c*, should be subjected to tension; whereas, they are really subjected to compression. The rule also decides that the lower bar is compressed, whereas it is extended. In justice to the rule, however, I should say that if we suppose that two inclined bars sustained the weight—neglecting the influence of the horizontal tie—it gives correct results. But with this admission I find that it fails in numerous instances in the arched truss. It can then be *relied upon only* in cases where two bars—and only two—are concerned in resisting the force. Tredgold applied it to such cases.

Robison in his Mechanical Philosophy, vol. i. p. 504, gives the following rule: "Take notice of the direction in which the piece acts from which the strain proceeds. Draw a line in that direction *from*

the point on which the strain is exerted; and let its length express the magnitude of this action. From its remote extremity draw lines parallel to the pieces on which the strain is exerted. If one of these lines cut the bar, or the bar prolonged in the direction of its remote end, the bar will be compressed; but if it cut the prolongation in the opposite direction it is a tie." This rule is also given in the Encyclopediæ Britanica in the article on Carpentry.

This rule is more nearly general than either of the preceding, and yet it must be used with caution and with some limitations. To illustrate it, refer to Fig. 19, and let A*a* represent the re-action of the supports, which is vertically upwards. Through *a* draw a line parallel to the lower chord; it cuts the bar A*d*; hence A*d* is a strut. Now the force in the strut acts from A towards *d*; therefore, draw *d e* in that direction from *d*, and proceed as before, and we see that the upper chord is compressed and the next bar extended. Proceed in this way until we come to the point where P is applied: or *generally; commence at either end and follow the rule to the point where the vertical shearing stress is zero.* The limitations to which I wished to refer, is—*we must not pass the point where the vertical shearing stress is zero.*

I have said the rule must be used with caution. For instance, in Fig. 19, to find the strains upon the bars which concentrate at *g*, we have found that the bar *d g* is a tie, and to produce tension on the part *g o*, it must act from *g* towards *o*; through *o* draw *o i* parallel to *m g*; it cuts A*g* at *i*; hence, we would be inclined to infer that A*g* is compressed, but we found while considering the forces at A, that it was extended. We must therefore infer that the point *i* belongs to the prolongation of *ng*; and hence *ng* is extended. If these cautions and limitations be observed I think that the rule will always give correct results.

My rule has been to observe that the inclined bars commencing at either end, are alternately compressed and extended up to the point where the shearing stress is zero; and that all parts of the upper chord are compressed, and of the lower are extended. It is not difficult to determine whether the first one is extended or compressed, and hence, the rule is easily applied.

In the next article I shall consider some cases in which the axis of Y intersects more than three bars.

(To be Continued.)

Mons. Crepin's Experiments on Baltic Timber Creosoted under Bethell's Process.

[Annales des Travaux Publics de Belgique.]

From the Lond. Practical Mechanic's Journal, August, 1864.

The experiments undertaken by me in 1857, at Ostend, to ascertain the relative preservation of timber prepared with sulphate of copper, and timber prepared with creosote oil, when placed in the sea, and the relative resistance of such differently prepared timber to the attacks of the Teredo worm, have been previously given to the scientific world.

I have proceeded with these experiments, and having again minutely inspected the creosoted wood, I am able to say that it presents no trace of the Teredo, and is in a perfect state of preservation. The experiments, I believe, may be now taken as decisive, and we may conclude that well creosoted fir timber, prepared with creosote oil of good quality, is proof against the attacks of the Teredo, and is certain to last for a long time.

Let us sum up the results of these experiments, or, at least, such as apply to the timber submerged in the sea, and exposed to the Teredo's attacks. This timber is placed exactly 1·90 met. (6 ft. 3 ins.) above the low-water mark of spring tides, so that the pieces between 2 met. and 2·60 met. (6 ft. 7 ins. and 8 ft. 7 ins.) long are left partly dry twice in the day. The Teredo greatly abounds at Ostend, and has been found in all situations below 1·90 met. (6 ft. 3 ins.) above the low-water mark of spring tides.

In the first fortnight of the month of October, 1857, I placed immediately beneath the line marking 1·90 met. (6 ft. 3 ins.) above the water mark, upon the piles of the east pier—

1. Three pieces of creosoted fir, which had been taken from a lot of wood prepared in the ordinary way by the State Railway.
2. Three pieces of beech prepared with sulphate of copper.
3. One piece of fir, and one piece of beech wood, not prepared in any way.

The first Inspection, 1859.—In the beginning of January, 1859, the above mentioned pieces were taken down and inspected.

It was found that the piece of fir unprepared was much perforated by the Teredo; that the piece of beech unprepared was perforated from one end to the other; that the pieces prepared with sulphate of copper were all three eaten by the Teredo; and that the three pieces of creosoted fir alone were intact, and without a trace of the Teredo.

The three last mentioned pieces alone were replaced, a slice having been previously cut off from each as a specimen; in two of the pieces the sawn surface was covered with flat-headed nails, but, in the case of the third, this precaution was purposely omitted.

The second Inspection, 1860.—The second inspection of the three pieces of creosoted wood took place in March, 1860.

Traces of the Teredo were discoverable in the piece, the sawn surface of which had not been covered with the flat-headed nails; but the two other pieces were altogether intact. Upon the heart wood portion of one of the sides, which probably had not been very fully impregnated with creosote, some very small holes of young Teredos were discovered, but it was plain that they had not been able to penetrate it at all. The two latter pieces were replaced.

The third Examination, 1862.—In the early part of July, 1862, the two pieces replaced in 1860 were re-examined, and presented no signs of the Teredo. They were then replaced as before.

The fourth Examination, 1864.—The two pieces replaced in 1862 were examined upon January 21st, 1864, and it was then found that they presented no trace of the Teredo, and no sign of decay of any

kind. These two pieces are now in as perfect a state of preservation as when they were first put into the sea, the wood has retained all its elasticity, and has acquired a density which it did not possess in its unprepared state; the creosote oil also appears to have been entering more deeply into the wood. These two pieces have been exposed to the Teredo from the month of October, 1857, to 21st January, 1864, —a period of more than six years.

They had, however, absorbed but a small proportion of creosote oil. They are now in a state of perfect preservation. The experiment appears to me conclusive.

However, as I said in the notice of this experiment inserted in volume xx of the "Annals," the Honorable the Minister of Public Works was so good as to order some pieces of wood to be prepared at Ghent on the 16th May, 1861, by the officers of the State Railway, expressly for my use; and I accordingly received 15 pieces then prepared, with which to make a further experiment. I fixed these 15 pieces in the first fortnight of June, 1861, upon the front row of piles of the east pier, all within 1·90 met. (6 ft. 3 ins.) above the low-water mark of the spring tides.

In the course of the winter of 1861, and the first month of 1862, three of these pieces, numbered 30, 33, and 40, were swept away by the sea, and lost.

The remaining 12 pieces were taken off, placed on the quay, and examined on the 11th July, 1862. After having ascertained that they bore no trace of the Teredo, I kept as samples numbers 16 and 18, and replaced the ten others.

These were taken down and examined on 21st January, 1864, and it was then again ascertained that they showed no trace of the Teredo, nor any kind of alteration or decay.

They are strongly impregnated with creosote, and the oil seems to have been penetrating more deeply into the wood. The wood is hard, and retains all its elasticity. On weighing the 10 pieces in question, I found that they had gained in weight, upon an average, 6·25 kilos. (14 lbs) each, during their immersion from 1862 to 1864. In 1862 we found that they had scarcely increased in weight at all, but the normal weight with which we compared them was, in this case, their weight as taken in the creosoting yard immediately after their preparation; and most probably this normal weight would have been less had they been weighed in the first instance upon their immersion in the sea at Ostend.

At all events, it is certain, that the weight of the creosoted pieces of wood is found to be increased after their immersion in the sea; they cannot therefore have lost in the sea any of the creosote oil with which they were impregnated. This circumstance is probably owing to the insolubility of the oil in the water, and also to the fact of its density being about equal to that of the sea water. It appears that, after its creosoting, and its subsequent immersion in the sea for two years and a half, the fir wood has nearly doubled in weight. It has acquired, and now retains, the density of oak.

This trial of creosoted fir for marine purposes appears to me conclusive, both as regards the preservation of the wood, and as regards its resistence to the Teredo. Experiments made in England, and recently in France and Holland, tend to the same conclusion. I cannot too strongly recommend the use of creosoted fir wood in Hydraulic engineering, in preference to oak (the price of which, especially for the larger pieces, has become excessive), since, in addition to its being cheaper, there is no doubt of the creosoted fir lasting longer. The Government Public Works Department has cordially adopted this most beneficial process, and constructed part of the dyke, and the whole of the American foot passengers' bridge in the new works at Ostend, of creosoted red fir.

At Nieuport, a visitors pier, 600 met. (660 feet), has been built of creosoted fir, upon the left bank of the channel; and the new pier, which is to be carried out from the end of it into the sea, will doubtless likewise be made of creosoted fir. Moreover, various sluice gates at Ostend have recently been ordered to be renewed, and creosoted Baltic fir and pitch pine to be used for that purpose.

The only things about which, to my mind, we need be solicitous, are *the proper creosoting of the timber with proper creosote oil, and the use of the proper kinds of timber*, viz., those best suited to the process of creosoting.

It has been observed that the resinous descriptions of wood become most thoroughly injected, and that the use of white fir should be discountenanced.

I also think it right to mention that, in the case of the sluice gates recently ordered, no limit has been fixed to the quantity of creosote which may be injected into the wood; also, that it is required that the wood be first subjected to a vacuum of 20 per cent. of the barometer for an hour; and immediately after this, have creosote oil forced into it at a pressure of 8 atmospheres during at least two hours.

OSTEND, February 5th, 1864.

MECHANICS, PHYSICS, AND CHEMISTRY.

An Account of Balloon Ascensions. By Mr. JAMES GLAISHER.

From the London Athenæum, Oct., 1864.

The Committee on balloon experiments was appointed last year for the following purposes:—To examine the electrical condition of the air at different heights; to verify the law of the decrease of temperature; and to compare the constants in different states of the atmosphere. With respect to the first of these objects, no progress had been made with the exception of preparing an instrument and apparatus for the investigation. At the request of the Committee, Mr. Fleeming Jenkin undertook the construction of the best instrument for the purpose, and one was finished towards the end of 1863, but it was constructed to be used with fire; it has since had to be adapted for water—a constant flow of which is necessary in electrical experiments in balloons.

This apparatus Mr. Glaisher was requested by the Committee not to use, as they felt that these instruments, if exerting no influence while the balloon was rising, might, when it was falling, throw considerable doubt on the experiments relating to humidity. With respect to the second of these objects, the verifying the law of the decrease of temperature in different states of the atmosphere, the Committee considered would be best attained by taking as many observations as possible, at times in the year, and at times in the day, at which no experiments had been made, for the purpose of determining whether the laws which hold good at noon apply equally well at all other times of the day. The Committee have always pressed the importance of magnetic observations in the higher regions of the air; the Astronomer Royal suggesting the use of a horizontal magnet, and taking the times of its vibration at different elevations, a method which is seldom practicable, owing to the almost constant revolution of the balloon. To obviate this, Dr. Lloyd suggested the use of a dipping-needle, placed horizontally when on the ground, by means of a magnet above it, so that, when in the balloon, the deviation from horizontality might be noticed, and which deviation would be independent of rotary motion of the balloon. The latter method has not yet been tried, Dr. Lloyd wishing some experiments to be made before the instrument was constructed; at Newcastle a very general wish being expressed that very high ascents should not again be attempted, none above five miles had since been made. Mr. Glaisher then gave an account of the ascents made by him during the past year. The first was from Newcastle, on the 31st of August. The balloon left the earth at 6h. 12m. P.M., with a north wind, and descended at five minutes past 7, at Pittington, near Durham. The decrease of temperature within the first 200 feet of the earth in this ascent was very remarkable, no such rapid decrease having been found in any other ascents. On the ground the temperature was 64°, and by the time 200 feet had been attained, a decrease of 8 degrees had taken place, the temperature being 56°; from this height to 1200 feet, there was but little change, and above this the temperature decreased from 2° to 3½° in each succeeding 1000 feet, up to 7000 feet when the balloon entered a relatively warmer current of air. The second ascent, on the 29th of September 1863, was from Wolverhampton. The gas on this occasion had been prepared in July, expressly for a high ascent intended to have taken place before the Newcastle Meeting, but circumstances prevented this being made, and the gas was obligingly stored in the gasometer by the directors of the gas-works. The balloon left at 7h. 43m. A.M., wind S.W. At 8200 feet there were two layers of clouds below the balloon and very dense clouds above. When at 11,000 feet, the clouds were still a mile higher; there was a sea of blue-tinged cloud below, and peeps of the earth was seen through the breaks. At 13,000 feet, high clouds were still above; but after this they began to dissipate, and at 9h. 38m., at 14,000 feet, the sun shone brightly. Ten minutes afterwards the travelers discovered the Wash at a distance of only ten miles, and were compelled to descend. A south-west gale was

blowing, and so strong was the wind that on the grapnels taking the ground near Sleaford, at 10h. 30m., the balloon was rent from top to bottom. In this ascent warm currents were met with at 8000 and 13,500 feet. In the descent a warm current was passed through, extending from 14,000 to 9000 feet. Temperature at the ground on leaving 48°; at time of descent 53°. On passing out of the mist at 3000 feet the humidity declined to 58° at 8000 feet; here there were dense clouds above and below; at 9000 feet the humidity was 71°; and then the air became suddenly dry. The third ascent was made from the Crystal Palace, at 4h. 29m., P.M., on the 9th of October. In seventeen minutes it was 7300 feet high, and directly over London Bridge, and all the vast number of buildings comprising the whole of London could be clearly seen. There were neither warm nor cold currents met with on this day. The Secretary of State for War having granted permission to the Committee to avail themselves of the facilities afforded in the Royal Arsenal at Woolwich, the ascent of the 12th of January was made from thence. It was intended to have been made on the 21st of December previous, and from time to time the balloon had been partially inflated. It left at 2h. 7m. P.M., and in 14 minutes had crossed the Tilbury Railway, and was over Hainault Forest; at 3h. 31m. the height of 12,000 feet was attained, when the balloon began to descend and touched the ground at 4h. 10m. at Lakenheath. On the earth the wind was S.E.; at 1300 feet a strong S.W. current was entered, in which the balloon continued up to 4000 feet, when the wind changed to S. At 8000 feet the wind changed to S.S.W., and afterwards to S.S.E. At 11,000 feet, fine granular snow was met with; and the balloon passed through snow on descending, till within 8000 feet of the earth. Clouds were entered at 7000 feet, which merged at about 6000 feet into mist. This ascent is the only one ever made in January for scientific purposes. The fifth ascent was designed to have been made as near the 21st of March as possible, but through adverse weather, was deferred to the 6th of April. The balloon left Woolwich at 4h. 7m. P.M., with a S.E. wind, ascending evenly at the rate of 1000 feet in about three minutes, till 11,000 feet was attained at 4h. 37m. It descended in the Wilderness Park, near Sevenoaks in Kent. Its course was most remarkable, having passed over the Thames into Essex; the balloon, unknown to the aëronauts, must have re-passed the river and moved in a directly opposite direction, and so continued till it approached the earth, when it again moved in the same direction as at first. The ascent is remarkable for the small decrease in temperature with increase of elevation. The air at the period of starting was 45½°, and did not decline at all until after reaching 300 feet, after which it decreased gradually to 33° at 4300 feet. A warm current was then entered, and the temperature increased till 7500 feet was attained, when 40° were attained, being the same as had been experienced at 1500 feet. It then decreased to 34° at 8800 feet, and then increased slowly to 37° at 11,000 feet, a temperature which had been experienced at the heights of 8500, 6500, and 3000 feet in ascending. After the great injury to

the balloon on the 29th of September, in addition to the repairs it had previously undergone, Mr. Coxwell did not consider it, after the additional rough usage in the last two voyages, safe for extreme high ascents, and determined to build a new one; which he did, capable of containing 10,000 cubic feet more gas than the old one, so that, if need be, two observers could ascend together to the height of five miles. A new balloon, however, needs trying in low ascents until it proves gas-tight, before it can be used for great elevations; and, on June 13, it was therefore started on a small ascent from the Crystal Palace, at 7 o'clock; the sky cloudless and the air perfectly clear, except in the direction of London. An elevation of 1000 feet was reached in 1¼ minute, 3000 feet at 7h. 8m., when the balloon descended to 2300 feet, and then re-ascended to 3400, when, after a slight dip, it again ascended to 3550 feet, the highest point by 7h. 28m., and then, after some oscillations, began its downward course at 7h. 50m. from 2800 feet, reaching the ground at East Horndon, five miles from Brentwood, at 8h. 14m. The remarkable feature in this voyage being that below 1800 feet elevation there was scarcely any change of temperature until the earth was reached. This fact, of no change in the temperature of the air at the time of sunset, was very remarkable, for it indicated that if such be a law, the law of decrease of temperature with increase of elevation may be reversed at night for some distance from the earth. June 20th the balloon left Derby, at 17 minutes past 6, P.M., and descended near Newark. June 27, the balloon ascended from the Crystal Palace, at 6h. 33½m., the sky cloudy, wind west. The descent was made on Romney Marsh, 5 miles from the shore. These several trial trips of the new balloon were made, and it was gradually becoming gas-tight, when its lamentable destruction at Leicester took place. The mayor of that town has recently presided over a meeting for the purpose of collecting subscriptions to assist Mr. Coxwell to re-build a new balloon; and we concur in Mr. Glaisher's wish that the town of Leicester and the Foresters' Society will soon remove the stigma resting upon them. Mr. Coxwell since then has had recourse to the old balloon, which he had repaired as best he could, and the next and last ascent of which Mr. Glaisher had to speak, was made with it, on August 29, from the Crystal Palace, at 4h. 6m. The difference between the temperatures of the air and those of the dew-point in this ascent was rather remarkable. The most important point in the past year's experiments are:—That though the law of decrease of temperature under ordinary circumstances in the Summer months is pretty well determined, we cannot say such a law holds good throughout the year; nor can we say that the laws which are in force during the day will be in force at night. In carrying out these experiments, Mr. Glaisher said he had freely given up all his leisure, and that Mr. Coxwell had done the same in the most unselfish manner; indeed, had it not been for the generous spirit in which Mr. Coxwell had entered into these experiments, they never could have been made, except at a multiple of the cost that had been incurred.

Proceedings of the Association for the Prevention of Steam Boiler Explosions, Manchester.

From the London Mechanics' Magazine, July, 1864.

[Report of the Chief Engineer, July 26, 1864.]

During the last month 218 engines have been examined, and 327 boilers, 14 of the latter being examined specially, and 6 of them tested with hydraulic pressure. Of the boiler examinations, 259 have been external, 11 internal, and 57 thorough. In the boilers examined, 173 defects have been discovered, 3 of them being dangerous.

No. 17 explosion occurred during last month, but as the investigation into all the circumstances connected with it was not completed when the last monthly report was issued, its consideration was postponed till the present occasion, and may now be entered upon.

Much as has already been stated in these reports as to the treacherous character of externally fired boilers, and the danger attendant upon their use, yet another fatal explosion of one of this class has to be recorded, which occurred, on this occasion, to a boiler under the inspection of this Association. By this explosion three persons were killed, and two others injured, one of them very seriously; while its occurrence only corroborates the views already expressed, and shows the necessity of the warnings which have been given.

The boiler in question was the centre one of a series of three, working at a colliery, all of them being of plain cylindrical egg-ended construction, externally fired, and each set with a flash flue. The length of the boiler was 37 ft., its diameter 6 ft. 6 ins., and the thickness of the plates from 3-8ths to 7-16ths-in.; while the safety valve was loaded to a pressure of 40 lbs. per square inch, which was by no means excessive for a boiler of such dimensions. It rent, as is so usual in these cases, through the line of rivet holes at one of the transverse seams, starting, in the first instance, at the bottom, and then running round the entire shell, and thus separating it into two pieces. In this instance the rupture occurred about mid-way in the length of the boiler, the firing end containing five widths or belts of plate, and being about 17 ft. 6 ins. long, and the chimney end containing six widths of plate, and being about 19 ft. 6 ins. long. These portions of the boiler flew in opposite directions, the firing end to a distance of about 170 yds. from its original seat, and the chimney end about 130 yards, or upwards of 1-6th of a mile apart.

The greater portion of the water with which the exploded boiler was fed was drawn from the workings of the pit, and was of a sedimentary character; while it was pumped into the boiler cold, and, in addition, the firing appears to have been severe. These are trying conditions for an externally fired boiler, and it is not, therefore, surprising that the seams of rivets over the fire gave way repeatedly; indeed such frequent repair was needed that as much as £200, as the proprietor stated at the inquest, had been expended in consequence on two of the boilers, though only three years old, the third one being new, and not as yet set to work. Only a few months ago the exploded

boiler had been newly bottomed at the furnace end for about half its length, five of the belts or widths of plate at the part over the fire having been renewed, and it was where the new work joined on to the old that the rent commenced; the rent running from rivet hole to rivet hole through the old plate which formed the inner overlap, while the new work did not give way. This rent did not run round the entire seam of rivets instantaneously, but opened for a short distance at the bottom in the first instance, and remained so for some days previous to the explosion. The attendants became aware of its existence from the leakage that occurred, and, on the Sunday previous to the explosion, the foreman in charge of the boilers got inside the one in question and, assisted by the smith, patched it in the following way:—In the first instance, they drove out four of the rivets, then laid over the crack a plate, which they daubed with horse dung, in order to make good the joint and stop the leakage, fastening the plate down by four bolts passed through the holes in the shell from which they had previously knocked out the rivets. In this plastered state the boiler worked on from the Monday morning till the following Saturday, when the explosion took place.

This does not appear to have been the first, but the third time that this system of patching had been adopted with this boiler, the identical plate used in this instance having been employed before for the same purpose, the foreman stating that he had been shown how to do it by the boiler-makers when previously executing some repairs at the colliery.

To those who still continue the use of these externally fired boilers the recommendations previously given can only be repeated, viz:—

1st. Heat the feed-water before its introduction to the boiler, and disperse it by means of a perforated pipe carried horizontally for several feet near to the surface of the water, and thus prevent its impingement on any particular spot, especially near the firing end.

2d. Where the water is at all sedimentary an efficient blow-out apparatus should be attached and regularly used. Surface blowing out by means of a scum pipe is particularly adapted to externally fired boilers.

3d. Do not allow the flames to act too intensely on any one spot, but spread the action over as extended a surface as possible, and lower the fire bars should any signs of distress appear at the seams of rivets.

4th. Have a spare boiler, so that defects may be suitably repaired immediately on detection, and the boilers regularly cleaned out without the necessity of Sunday work, a practice which is unadvisable though regarded only from an engineering point of view, is demoralizing in its influence upon the workmen, and expensive to the steam user.

5th. With regard to the construction of the boiler, secure good workmanship and material in the first instance. It is a mistake to consider that externally fired boilers are better for being made of thick plates. Those under inspection which have given the least trouble have not been more than three-eighths of an inch in thickness, and it

is thought that in plain cylindrical boilers this thickness should not be exceeded. In effecting repairs, as well as in the first construction, the rivet holes should be brought fairly one over the other, without straining, while drifting should not be allowed. In putting in new plates to old boilers, it will in many cases be advisable to cut away the old line of rivet holes and drill new ones; while the new work should rather be thinner than the old, instead of being thicker, as it sometimes is. These are, however, but ameliorative measures; while it is thought a more radical cure would be found in condemning these plain cylindrical externally fired boilers altogether and adopting those internally fired in their place. It surely is no argument to object that the Lancashire type of boiler, though successfully introduced into mills, is inapplicable to colliery purposes on account of the rough usage to which it would be exposed, since this is to make carelessness its own excuse, and to put a stop to all improvement. Although it can scarcely be necessary, yet it may perhaps be stated, in conclusion, that this Association must receive the co-operation of its members if it is to protect their boilers from explosion, and all its responsibility must clearly cease, if between the times of its periodical inspection, the boilers are allowed, as in the present instance, to be patched and plastered without its knowledge.

Lecture on Light. By Professor ROSCOE.

From the London Mechanics' Magazine, September, 1864.

Read before the British Association.

The light emitted by burning magnesium wire is exceedingly rich in chemical rays—so much so that this light may be used instead of sunlight for the purpose of photography. As an illustration of this I will endeavor, with Mr. Brother's assistance, to take a photograph of our President, if he will kindly permit me to do so. [Sir Charles Lyell here took a seat in front of the white board, and, by the light of burning magnesium wire, a negative was taken, from which a print was obtained in sufficient time to enable a capital positive to be thrown upon the screen by the aid of the oxyhydrogen light before the audience dispersed. The result was loudly cheered.] The spectrum of burning magnesium is exceedingly rich in violet and ultra-violet rays, partly due to the incandescent vapor of magnesia, and partly to the intensely heated magnesia formed by the combustion. So long ago as 1859 the chemically active power possessed by this light, compared with that of the sun, was determined, and the use of this light for the purpose of photography was proposed. It was shown that a burning surface of magnesium wire, which seen from a point at the sea level, has an apparent magnitude equal to that of the sun, effects on that point the same amount of chemical action as the sun would do if shining from a cloudless sky at a height of 99 degs. 53 mins. above the horizon. On comparing the visible brightness of these two sources of light, it was found that the brightness of the sun's disk as measured by the eye, is 524 times as great as that of burning magnesium when the sun's

zenith distance is 67 degs. 22 mins.; whilst at the same zenith distance the sun's chemical brightness is only five times as great. Hence the value of this light as a source of the chemically active rays for photographic purposes becomes at once apparent. In the memoirs published in the above year it is stated that the steady and equable light evolved by magnesium wire burning in the air, and the immense chemical action thus produced, render this source of light valuable as a simple means of obtaining a given quantity of chemical illumination, and that the combustion of this metal constitutes so definite and simple a source of light for the purposes of photo-chemical measurement, that the wide distribution of magnesium becomes desirable. The application of this metal as a source of light may become even of technical importance. A burning magnesium wire, of the thickness of 0·297 millimetre, evolves as much light as 74 stearine candles, of which 5 go to the pound. If this light lasted one minute, 0·987 metre of wire, weighing 0·120 gramme, would be burnt. In order to produce a light equal to 74 stearine candles burning for 20 hours, whereby about 20 lbs. of stearine is consumed, 72·02 grammes (two-and-a-half ounces) of magnesium would be required. The magnesium wire can be easily prepared by forcing out the metal from a heated steel press having a fine opening at bottom; this wire might be rolled up in coils upon a spindle, which could be made to revolve by clock-work, and thus the end of the wire guided by passing through a groove or between rollers, could be continually pushed forward into a gas or spirit lamp flame, in which it would burn.

The manufacture of this metal is now carried on under Mr. Sonstadt's patent, by the Magnesium Metal Company of Manchester, and the light evolved by the burning wire is likely to be applied to very many technical purposes.

Some persons are sanguine enough to believe that it may be used for illuminating our streets, and I understand that the gentlemen who manufactured the metal have an application from the managers of the gas works at Rio de Janeiro, who seem to think it would be better for them there to light with magnesium wire instead of gas. I believe this is a serious proposal, but we can scarcely expect that it will be carried out in practice. In conclusion, I have only to thank you for the very kind way in which you have listened to me.

Gun Cotton.

From the London Mechanics' Magazine, September, 1864.

Messrs. Pelouze and Maurey, in a memoir presented at the last meeting of the Paris Academy of Sciences, state it as their opinion, derived from a long and careful investigation of the subject of gun cotton, that that explosive compound, if now better known as far as its composition, mode of production, and properties are concerned, is still, with regard to its employment in fire-arms, in the same position as it was in 1846. "Nothing, in fact authorizes us to believe that it is possible, in the present state of our knowledge, either to prevent its spontaneous combustion or to correct in a practical manner it liability to burst the weapons at present used for gunpowder."

On Machinery for the Manufacture of Plate Glass. By Mr. George H. Daglish, of St. Helen's.

From Newton's London Journal of Arts, July, 1864.

Within the last ten years the production of plate glass in England has been quadrupled, whilst in the same time the price has been diminished fully one-half. The present extent of the manufacture in this country is about 85,000 square feet per week, whilst about 12,000 square feet per week of foreign plate glass is imported. The foreign glass has obtained a preference, from its superior lightness of color, which arises from the greater purity of the materials that it is made of, particularly with regard to the sand, of which the foreign makers have an abundant supply, of great purity and light color, as seen from the exhibited specimens of English and foreign sand.

Under the influence of competition, the English manufacturers have lately commenced an extensive course of experiments, with the view of improving the quality of their plate glass, and also reducing the cost of manufacture; and in some instances very decided success has thus far been the result. In order to accomplish these objects, the sand employed at the British Plate Glass Works at Ravenhead, near St. Helen's, is now imported from France; and every precaution is adopted to ensure as far as possible the chemical purity of the other ingredients of the glass. At these works, also, two of Mr. Siemen's regenerative gas furnaces have been erected for melting the materials; and, from the absence of smoke and dust in them, and the facilities they afford for regulating the heat, these furnaces have contributed greatly to the desired results. Under these altered circumstances, the glass now manufactured is fully equal to the best samples of the French production.

As time is money, any improvement which tends to expedite the manufacture of glass is of importance. This is strongly exemplified in the process of annealing. After the materials have undergone the process of melting in the furnace, and are considered in a fit state for casting, the pot containing the melted mass is taken to the casting table, and its contents poured out on one end of the table, in front of a large cast iron roller; the material is then spread out by passing the roller over the surface of the table; the thickness of the plate of glass being regulated by strips of iron placed along each side of the table, on which the ends of the roller run. As soon as the plate of glass is sufficiently solidified to bear removal, it is introduced into an annealing oven, there to be gradually reduced in temperature or "annealed," until it is fit to be exposed to the atmosphere without risk of fracture. This process of annealing used formerly to occupy upwards of a fortnight; but, from the improved arrangement and construction of the annealing oven, it is now completed in four days. Thus three times the quantity of glass can now be annealed in each oven, compared with what was formerly considered possible; and consequently a large outlay in building and in space has been saved, since only one layer of plates can be placed in the oven at one time; no method of piling the plates

being considered practicable, or even safe. The chemical difficulties and manipulation in producing the raw material have thus been very satisfactorily overcome; but the problem of carrying out the necessary improvements in the subsequent mechanical operations has not perhaps been so completely solved, though considerable strides have been made in that direction also.

The plates of glass, when taken from the annealing ovens, are exceedingly irregular, particularly on the surface which has been uppermost in the process of casting,—that surface being undulated or wavy after the passage of the roller over it whilst in a semi-fluid state; the lower side, too, is affected by any irregularities on the surface of the casting table, and also to some extent by the floor of the annealing oven; and both sides of the plates are also covered with a hard skin, semi-opaque. The plates vary in size, the largest being about 17 feet long by 9½ feet wide, and the thickness varies, according to the size, from ⅜-inch to ⅝-inch. The first process to which the plates are submitted is that of grinding, to take off the hard skin and reduce the surface to a uniform plane, which is performed by the application of sand and water. The second process is that of smoothing, which is a continuation of the first process, but performed with emery of seven different degrees of fineness, so as to prepare the surface of the glass for the final process of polishing. This last process is effected by the use of oxide of iron employed in a moist state.

The machine in general use for grinding is that which was originally employed at the commencement of the glass manufacture, and is believed to have been designed by James Watt. It is known by the name of the "fly-frame," machine. It consists of two benches of stone, sufficiently large to hold a plate of glass, and placed about 12 feet apart: on these benches the plates of glass are fixed by plaster of Paris. Each bench has a runner frame made of wood, about 8 feet long by 4½ feet wide, shod on the under side with plates of iron about 4 ins. broad and ¼-inch thick, and provided with a strong wrought iron stud on the upper side, by which it is moved about over the surface of the glass. The gearing for driving these two runner frames is placed between the two benches, and consists of a square cast iron fly frame, with two flat bars hinged to it on opposite sides, extending over each bench, and suspended from the roof by long chains, so as to allow them to radiate freely in every direction: this is called the "fly frame," from the peculiar motion given to it, and each of the runner frames is connected to it by a central stud working loosely in the slot between the flat bars. The fly frame receives its motion from an upright spindle, which is driven from the main line of shafting by a pair of bevil wheels, with a friction clutch for throwing in and out of gear. On the top of the spindle is a wrought iron arm or crank carrying a movable stud, which works in a bush in the centre of the fly frame. Round the centre spindle are also four other spindles, equidistant from the centre spindle and from one another, each carrying on the top a wrought iron crank arm, with movable stud, similar to the centre one: these studs severally work in bushes at each corner of the fly frame. Hence, when

motion is given to the centre spindle, the fly frame is carried round by the stud on the crank arm, while its sides are always kept parallel to their original position by the four corner cranks. The two runner frames, being connected by their central stud to the arms of the fly frame, receive the same circular motion as the fly frame; but at the same time they are left free to revolve round their own centres, which they do in a greater or less degree, according to the varying friction of the grinding surfaces. The grinding motion being thus obtained, sand and water are constantly applied, until the surface of the glass is found, upon examination, to be free from all defects; the sand is then washed off the glass, and the first stage of the smoothing process is commenced on the same machine, by substituting the coarser qualities of emery in place of the sand. The plate of glass is then removed from the bench, turned over and replaced on the bench, and submitted to the same process on the other side. The speed at which the fly frame is driven is about forty revolutions per minute. As the runner frame is not sufficiently large to act upon the entire surface of a large plate of glass at one time, it is necessary to divide the operation, and shift the position of the runner frame as the work requires it, by inserting the centre stud of the runner frame in a different portion of the slot between the fly frame bars.

Until the last few years, the principal part of the operation of smoothing was effected by manual labor,—the operation being performed by rubbing two pieces of glass together, and applying emery powder between them. Great care is requisite, as the work approaches completion, that no scratching shall take place; and it is on this accouut that hand labor is considered absolutely necessary for finishing the process, the slightest scratch being immediately felt by a practised hand, whilst a single stray particle of grit on a machine would spoil the whole surface before it was perceived. About 1857 Mr. Crossley introduced a machine for smoothing the plates of glass, which so far succeeded, that the nicety of the hand-touch is only required for the final part of the operation. This smoothing machine is exceedingly simple and inexpensive. It consists of a long wooden bar, connected at one end to a crank on an upright spindle, and extending over the stone bench on which the plate of glass is laid: two runner frames of wood are attached to the bar, and on the under side of each frame is fixed another plate of glass; these are then laid upon the glass on the bench. In this case the runner frames are only allowed to partake of the motion given to them by the bar, and are not left free to revolve round their own centres, as in the grinding operation previously described. The centre of the bar between the two runner frames is kept in position by a radius rod secured to a fixed bracket on one side of the bench, at right angles to the direction of the bar. The crank being set in motion, the bar and runner frames receive a movement somewhat similar to the figure 8, which is very similar to the motion given in manual labor. One advantage of this machine is, that two surfaces of glass are finished at one operation. The space between the two runner frames is found very

convenient for applying the emery, and also ascertaining the progress of the work, without having to stop the machine.

The machinery used in the polishing process remains the same in principle as that originally constructed for the purpose. Each machine consists of a strong cast iron frame, about eighteen feet long by ten feet wide, containing a series of small rollers, upon which is placed a wooden table with two racks on the under side; suitable gearing is connected to these racks, to give the table a slow alternate lateral motion, so as to bring every part of the plate of glass under the action of the rubbers or polishers. The plates of glass are fixed upon the table by plaster of Paris, and the ends of the table move between slide blocks secured to the main frame, so as to prevent the action of the rubbers from displacing it. The rubber blocks are pieces of wood, covered with felt, and provided with a central spindle and adjustable weights, to regulate the amount of friction; a number of these blocks are secured to two movable bars, running on rollers, at each end of the table, and driven by a short shaft, with cranks at the ends, set at right angles to each other. The rubber blocks are thus worked transversely to the motion of the table; and by applying the polishing powder in a liquid state, the surface of the glass is gradually brought up to the requisite degree of polish, both sides of the plate successively being subjected to the same operation.

About 1857, experiments were commenced at the British Plate Glass Works at Ravenhead, with an entirely different class of machinery for grinding and smoothing plate glass, with the object of increasing the production, reducing the cost, and also completing the process of smoothing upon the same machine on which the glass is ground, so as to obviate the necessity of a separate machine for smoothing, and also save the expense and loss of time in removing and refixing the plates of glass. The new grinding and smoothing machine consists of a revolving table, twenty feet diameter, fixed upon a strong cast iron spindle, and running at an average speed of twenty-five revolutions per minute, driven through an intermediate upright shaft from the main line of shafting by a pair of bevil wheels, and friction cone, for throwing in and out of gear. This arrangement of gearing for driving the table was made by Mr. Daglish, and was adopted in order to obtain a spindle for the table of a length equal to the semi-diameter of the table, and at the same time to keep the main line of shafting continuous for driving a series of tables in one room. Over the top of the table a strong timber bar is fixed, about ten inches from its surface; and on the two opposite sides of this bar are bolted two notched plates of cast iron, one on each side of the centre of the table. The notches are for receiving the centre studs of the runner frames, which are very similar to those used on the old class of machinery; and the runners can thus readily be moved nearer to or further from the centre of the table, as circumstances require, by shifting the stud into a different notch. The only motion which these runner frames have is round their own centres, and this is given to them by the excess of friction on the side furthest from the centre of the table over that on the side nearest to the centre,

this excess being caused by the greater velocity of the portion of the table further from the centre. It is evident that the amount of grinding action is considerably greater on this machine than upon the old one, both from the increased velocity of the runner frames themselves, and also from the double amount of movement obtained by the revolution of the table and the runner frames. The idea of driving the runner frames themselves, as well as the table, was conceived at an early stage of the experiment; but on being put to the test, it was found that the unaided movement of the runner frames adapted itself to the work to be performed far better than any compulsory motion could do. It has also the advantage of leaving the surface of the table free and unencumbered with any machinery, and consequently facilitates the operation of laying and removing the plates of glass: the whole of the driving machinery is also covered over, and thus protected from the injurious effects of the sand and water thrown off from the edge of the table in working.

This machine has been found to answer equally well for smoothing as for grinding; and this is perhaps its most successful feature in a commercial and economical point of view. Both these processes are now completed on it at the Ravenhead Glass Works; the finishing portion of the smoothing operation alone being effected by manual labor for the reasons before stated. The plates of glass being generally oblong in form, it was found that the machine in its original shape, having a circular table for carrying the glass, entailed considerable waste in filling up the area of each table for grinding; and it was then determined to alter the shape to that of an unequal-sided octagon, or square with the corners taken off. No difficulty has been experienced in the process of grinding from this alteration in form, whilst the amount of waste in making up the tables has been considerably reduced, and greater facilities are obtained for grinding large plates. The amount of wear and tear on this machine has been found to be very small in comparison with the old machines, owing to the small number of working parts, the large extent of bearing surface, the smoothness of the motion, and the complete balancing of the table. The quantity of glass finished upon one of these machines per week is from 1200 to 1500 square feet, which is about one-third more than the old machines are capable of doing, due allowance being made for the difference of area in them.

The first point to which attention should be directed for working out further improvements is the method adopted in casting the plates of glass, and the machinery employed to carry out the process. It has been stated that the plates of glass in their rough state are very irregular, so much so that about 40 per cent. of the glass is ground away in the subsequent processes, which is a serious waste of material, and entails a great expenditure of time and material in the process of grinding; it is therefore worthy of consideration, whether some improvement may not be carried out in this direction by obtaining the plates of glass smoother in the first instance. The grinding and smoothing operations are believed to be now improved upon the previous practice, though

there is no doubt room for further practical suggestions and appliances. The polishing process has been tried to a limited extent on the revolving table last described, but without any practical advantage: the present system is, no doubt, theoretically correct, as the action of the rubbers is regular and uniform over the whole surface of the glass, thus keeping up a uniform temperature; but some motion producing a continuous movement of the rubbers, instead of the present alternate movement, would no doubt reduce the wear and tear, and require less power, and would probably also be found capable of a higher velocity, resulting in an increase of production, provided the other requisite conditions of the process were complied with.

Mr. Windus exhibited specimens of the plate glass from the several stages of the manufacture, in the rough state after casting, and after each of the processes of grinding, smoothing, and polishing. He also showed specimens of plate glass made from English and from French sand, together with the samples of the sand from which they were made, showing the lighter color and greater purity of the French sand.

Mr. F. J. Bramwell observed that reference had been made in the paper to the highly satisfactory working of Mr. Siemen's regenerative gas furnace, as applied for melting the materials to make the glass at the Ravenhead Works: he had, as engineer to the company, recommended the adoption of that furnace for the purpose, being convinced of the great advantages that would be found to attend its use, and the first furnace on that construction had now been in constant work for fifteen months, and a second and larger furnace had been erected in May last, which had also been in constant work since that time. These furnaces, he believed, left nothing to be desired as far as regarded the melting; but in other respects he thought the process of making plate glass was at present in a most unsatisfactory position, and some improvements seemed to be much wanted in the mechanical contrivances used in the manufacture, though he must admit it was more easy to make that assertion than to show how the improvements were to be effected. A serious objection to the present arrangement was the great amount of handling that the plates of glass had to undergo in the several processes, which was evidently an important point when it was considered that the large plates fetched a higher price per square foot than smaller ones, and therefore it was desirable to avoid the risk of having to cut up large plates into smaller sizes on account of fractures. Under the present methods, however, the risk of fracture was great, from the number of times the plates were handled: on leaving the annealing oven, the plate was handled once in conveying it to the grinding machine and bedding it there, and afterwards a second time in turning it over for grinding the second side; and similarly it had to be twice handled for each of the subsequent processes of smoothing and polishing,—making six times of handling altogether before the plate of glass was finished on the machines; after which it had still to be twice handled in the final operation of hand cleaning. All these processes, he considered, ought to be effected without more than

twice laying the plate,—once for each side; or even without laying the plate at all, by working on both sides of it simultaneously: and in this respect, therefore, he thought there was a wide field open for improvements in the plate-glass manufacture.

The revolving grinding table that had been described was a decided improvement upon the old fly frame grinding machine, since, in all mechanical operations, it was better to get rid of a reciprocating action wherever practicable, and replace it by a continuous circular motion. The new construction of grinding table was preferable to the old grinding benches, on account of its protecting all the machinery below it, so that the working parts and bearings were not exposed to injury from the grit thrown off profusely from the grinding table. A further advantage was the large size of the table, twenty feet diameter, which afforded room for working on the whole surface of a large plate of glass at once.

A serious cause of loss at present in the manufacture was the very large proportion of the glass that had to be removed in the process of grinding in order to obtain a level surface of the glass. The undulations on the surface of the plates before grinding could not, he considered, be produced by the roller on the casting table, as had been suggested, because the roller was of great weight and was moved forwards steadily, running at each end on a smooth strip of iron laid along each side of the casting table, by which the thickness of the plate of glass was determined: the surface of the glass appeared level before the plate was put into the annealing oven. The undulations, after annealing, were not in parallel furrows across the plates, but were in the form of hills and hollows, altogether irregular in size and position. It therefore appeared that the glass, in annealing, must contract irregularly, causing this uneveness of the surface, particularly on the side which had laid uppermost in the annealing oven; in consequence of which a large proportion of the glass had to be ground away as waste, in order to obtain a level surface. In the old annealing ovens, the plates had to be left a long time till the oven had cooled down of itself; but the ovens were now built with air channels under the bed, through which a current of cold air passed; so that the heat was reduced as quickly as was practicable without injury to the glass, whereby a great saving of time was effected. No method, however, had yet been devised for laying the plates one on another in the annealing oven, and consequently a large area of surface was required in the ovens, in order to lay them all separately, some of the ovens being as much as fifty feet long, for the purpose of annealing six large plates of glass at a time. The ovens were well designed for uniformity of heat in all parts, notwithstanding their great size.

Mr. R. Pilkington thought the reason of the uneven surface produced on some of the glass plates in annealing was, that the oven was made too hot for the first plates that were put into it, in order that it might be hot enough for the last ones; and consequently the earlier plates had not become sufficiently set with a uniform degree of hardness before going into the oven. The glass certainly went into the

oven quite smooth, and the unevenness must therefore arise in the annealing. At the St. Helen's Plate Glass Works they made what was known as Hartley's plate, fluted plates of glass, half-inch thick, and these were annealed by being piled on the edge in a vertical annealing oven, as they were strong enough to stand on the edge in consequence of their corrugated form. A plan had also been tried of laying the flat plates one upon another in the annealing oven, by means of a lowering table in the oven; but the objection to this plan was, that if the plates were at all too hot, they stuck together, and could not be separated again without breaking.

On the Supposed Nature of Air prior to the Discovery of Oxygen.

By GEORGE F. RODWELL, F.C.S.

From the London Chemical News, No. 233.

(Continued from page 325.)

6. *Thomas Hobbes.*—On the discovery of the Torricellian vacuum, philosophers became divided into two sects, called respectively "Vacuists" and "Plenists," the former maintaining that a vacuum was possible and capable of being obtained by certain physical processes, the latter that the world was everywhere full, and the production of a vacuum impossible. Among the Vacuists were Otto von Guericke, Pascal, Boyle, and the greater number of the experimental philosophers who were in the habit of meeting at Gresham College for the discussion of scientific matters; and among the Plenists were Marsennus, Noel, Thomas Hobbes, Franciscus, Linus, and the Cartesians:—of these latter Boyle writes "the subtilest and wariest champions for a plenum I have yet met with."

We have previously* spoken of Noel and Marsennus, and we have now to consider the opinions of Thomas Hobbes.†

Of the theological and mathematical writings of Hobbes I can have nothing to say here, but I consider that views put forward in his philosophical treatises, in so far as they relate to the air, are far less advanced than those of his contemporaries—less advanced, indeed, than those of many of the ancient philosophers who preceded him by nearly twenty centuries. Although intimately acquainted with Bacon an Galileo, the fathers of experimental philosophy, he was himself no experimental philosopher, but he preferred to prove his assertions by reasoning rather than by well founded observation and experiment. He deprecated the trying of experiments, and was specially bitter against the recently formed Society of Experimental Philosophers, the object of which was to do away with the baseless structure of the old speculative philosophy and to found a new philosophy resting on a solid experimental basis.

The language which Hobbes employs in controversy abounds with vituperation, and is in every way utterly unbecoming a philosopher. His arguments are frequently puerile and without weight, and the

* See the third of these papers, CHEM. NEWS, vol. viii., p. 246.

† Born 1588. Died 1679.

objections which he urges in order to prove the fallacy of a theory or experiment are often paltry and trifling. In the following words* he addresses Dr. Ward and Dr. Wallis, who had opposed some of his views:—"But I here dismiss you both together. So go your ways, you uncivil Ecclesiastics, inhumane Divines, Dedoctors of morality, unasinous Colleagues, egregious pair of Issachars, most wretched Vindices† and Indices Academiarum, and remember Vespasian's law,‡ that it is uncivil to give ill language first, but civil and lawful to return it.

Hobbes himself did not always remember the first sentence of the law, but assuredly he never forgot the last; it is right to add, however, that the learned Savilian professors were by no means so tolerant in the controversy as they might have been, and although they did not make use of such contumelious epithets as Hobbes employs, they occasionally made rather offensive puns on his name:—it is curious, in a treatise devoted to the explanation of some problem in the higher mathematics, to find such words as "*hob*-goblin."

Hobbes did not turn his attention to natural philosophy till somewhat late in life; his adoption of the views of the Plenists may probably be accounted for by the fact that he was well acquainted with Mersennus and Des Cartes, two of the most notorious of the Plenists. In some of his physical views he was almost a Cartesian.

Hobbes did not admit the condensation or rarefaction of matter; he believed the whole world to be full, and that it could not be fuller than full or less full than full.

He conceived that the air consists of an ethereal substance extending as far as the sun, in which ether, myriads of hard atoms possessing simple circular motion of their own, move; these atoms exist in greater quantity near the surface of the earth than at some distance above it. He denied that the air possesses either weight or elasticity. "Utraque illa phantasia," he writes, "tum gravitatis atmosphæræ, tum vis elasticæ sive antitupiæ§ aëris, somnium erat."

Hobbes adduces a very simple experiment to prove the universality of a Plenum, an experiment for the production of which there was required neither expensive apparatus nor careful manipulation, for the sole apparatus was a gardener's watering-pot, and the experiment was

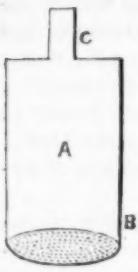
* See "Lessons on the Principles of Geometry, to the Egregious Professors of the Mathematics, one of Geometry, the other of Astronomy, in the Chairs set up by the noble and learned Sir Henry Savile in the University of Oxford." Lesson vi., "On Manners."

† Ward had written a work entitled "Vindiciæ Academiarum."

‡ Hobbes alludes to the following saying attributed to Vespasian, "Maledici senatoribus non oportere; remaledicere fas et civile esse."

§ From αντιτυπτω, repel a blow, to re-act; a scarcely appropriate term to apply to an elastic body; inasmuch as elasticity signifies that property possessed by the atoms of certain bodies, in virtue of which when their relative positions is altered by the addition of force, or the removal of force previously acting, they return to the position which they occupied prior to the addition or subtraction of that force.

made whenever it was used. The watering-pot, which was in use 200 years ago, consisted of a circular vessel A, the bottom of which, B, was pierced with a number of minute holes; it was terminated above by an opening, C, capable of being closed by the finger. Water would obviously be retained in such a vessel by the pressure of the air as long as C remained closed, but directly it was opened water would flow from the bottom of the vessel. That no water flows from A until C is opened is, according to Hobbes, positive proof of a plenum, for, he reasons, as the world is full, there is no place for the water to go into until C is unstopped, when the air, which is dispaced by the descending water, enters and takes the place of the water which flows from the vessel. "And this," he writes, "I take for a sign that all space is full; for without this the natural motion of the water, which is a heavy body downwards, would not be hindered."*



As Hobbes was a plenist, he of course contended that Boyle's air-pump did not produce a vacuum. He speaks of it as being "of the nature of a pop-gun which children use, but great, costly, and more ingenious," and he maintains that the effects produced by it are such as would be produced by a strong wind cooped up in a narrow room. In the first place, when the piston is drawn from one end of the cylinder to the other, he affirms that no air is removed, but sufficient "pure air" to fill the space deserted by the piston enters between it and the surface of the cylinder; for, although the piston was closely fitted into the cylinder with well-oiled leather, it may, he says, keep out "straws and feathers," but not air, "for the body of leather will give passage both to air and water, as you will confess when you ride in rainy and windy weather." (It was by trifling arguments of this kind that Hobbes sought to confute results obtained by one of the most careful and persevering experimenters of the day.) The pure air which forcibly enters between the piston and the surface of the cylinder generates a most violent motion of the air within the air-pump receiver, and this violently-agitated air produces all the effects observed in the receiver after long-continued pumping.

Animals suffer death in the receiver because the rapid motion of the air stops the passage of their blood, but here Hobbes' argument is greatly at fault, for he states elsewhere that the air supports life, because when we breathe we draw in a great number of the swiftly-moving atoms in the air, which pass into the blood, and by their motion cause it to circulate through the veins and arteries; if this be the case, and the above theory obtains, animals ought obviously to have a quicker circulation of blood in the receiver; thus one theory destroys the other, and one is nullified before it leaves the hands of its propounder.

* See "The English Works of Thomas Hobbes, of Malmesbury, now first collected and edited by Sir William Molesworth." Eleven vols. 1839-1845.

Boyle* has very ably answered all the objections which Hobbes raises against his "Physico-Mechanical Experiments," and the instruments which he employed for their production, and although first attacked, and somewhat violently too, he carries on the controversy in a far more tolerant spirit than that exhibited by his adversary.

As in the air-pump Hobbes admitted no rarefaction of the air, so in the air-gun† he admitted no condensation. By working the piston, he contends, large numbers of the hard atoms in the air are forced into the gun, while the pure air escapes between the surfaces of the piston and the syringe; the motion of the injected hard particles becomes greater and greater with every stroke of the piston, and finally when the valve is opened the particles rush out violently, and carry with them a bullet or anything else in their path.

Hobbes, in common with the Plenists, did not allow that the space above the mercury in the Torricellian experiment is a vacuum; his explanation of the suspension of the mercury in the tube is very difficult to understand; he seems to have thought that the weight of the mercury column presses a certain amount of air into the upper part of the tube, and that the column comes to rest when the weight of the mercury is "equal to the force which is required in air to go through it."

It had long been known that nitre when thrown on red hot coals engenders very rapid combustion; Hobbes explains this by supposing that nitre consists of "many orbs of salt filled with air," which air rushing violently from the nitre meets particles issuing from the burning coal in an opposite direction, and the two contrary motions produce the intense inflammation observed.

Hobbes was well aware that in many coal mines there exists a kind of matter which suffocates living creatures, and extinguishes flame; he speaks of it as "a certain matter of a middle nature between water and air," and as being perfectly transparent and not much lighter than water; elsewhere he speaks of the deadly fumes given off by burning charcoal, as consisting of a "flameless glowing fire, which dissipates those atoms that maintain the circulation of the blood." I do not find, however, that he traces any connexion between the suffocating gas of coal mines and the suffocating gas of burning charcoal.

Hobbes believed winds to be produced by clouds which descend by their own weight, and strike down the air beneath them; when the dejected masses of air reach the earth they rebound, and thus lateral

* See "An Examen of Mr. T. Hobbes, his Dialogus Physicus de Natura Aeris. As far as it concerns Mr. R. Boyle's book of new experiments touching the spring of the air, &c., By the Author of those Experimints." London. 1662. Also, "Animadversions upon Mr. Hobbes' Problemata de Vacuo." By the Hon. Robert Boyle, Fellow of the Royal Society. London. 1674.

† The air-gun was invented by M. Marin Bourgeois in 1607. The first account of it is given in a work entitled "Les Elemens de l'Artillerie: concernans tant la theorie que la pratique du Canon. Augmentés en cette nouvelle edition et enrichis de l'invention, description, et demonstration d'une nouvelle artillerie que ne se charge que d'air ou d'eau pure, et a neanmoins une incroiable force, &c. Le tout par le sieur de Flurance Rivaul. Paris, 1608." There is a good copy of this curious work in the British Museum Library.

winds moving in all directions are generated. Thunder and lightning are caused by air enclosed in hollow frozen clouds, which air being more and more pressed, at length the ethereal part of it passes out of the cloud, but a great number of hard particles endued with violent motion remain, and ultimately exert such force that the ice is suddenly broken, and the noise produced by the disruption is thunder.

The learned editor of Hobbes' works speaks of him as "one of the greatest and most original thinkers in the English language." We speak here solely of his merits as a physical philosopher, and I think it will be admitted that he was neither a great physicist nor a man calculated to forward the interests of the then young experimental philosophy. But was it to be expected that the old speculative philosophy would be overthrown at the first onset? was it to be expected that its disciples would see their fabric destroyed without one blow in its defence? a radical change is never made without opposition, never established without a stuggle, and the more violently that struggle the more surely and completely will the change be effected. Hobbes was a follower of the old philosophy, now about to be expelled from the human mind: he lived at the period of the change: should he not rise in the defence of that for which he had devoted his best energies? should he not make an effort to stem that tide which was so rapidly gaining ground?

Men like Hobbes (and we find many such in the history of Science), who rather than allow the falsity of an old and favorite theory, frame a more false theory to support it, even such men indirectly benefit Experimental Philosophy, for by propounding a fallacious theory, they cause experiments to be made for its refutation; and no experiment is made in vain, each one is another stone added to the great and rapidly-increasing structure of our Philosophy.

(To be Continued.)

Specification of a Patent granted to MAX PATTENKOFER, *for restoring the Surface of Pictures in oil without any danger to their Original state.*—[Dated 20th October, 1863.

From Newton's London Journal of Arts, July, 1864.

Observation and experiment show that the changed appearance noticed in varnished pictures in oil, after the lapse of some years, is caused in most cases by physical and not chemical influences. Time causes in these objects the discontinuance of molecular cohesion. The process begins on the surface with microscopical fissures in the varnish, and penetrates by and by through the different coats of colors to the very foundation. The surface and body of such a picture becomes in the course of time intimately mixed with air, and reflects light like powdered glass, or loses its transparency like oil intimately mixed with water or air. The best method of rejoining the separated molecules without any danger or damage to the original, is the following:—The picture is exposed to an atmosphere saturated with vapor of alcohol

at the ordinary temperature (without applying heat). The resinous particles of the picture absorb alcohol from that atmosphere until they are saturated, and not more. By this process the different separated molecules re-acquire cohesion with each other, and the optical effect of the orginal is restored soley by self-action, the picture not getting touched at all. The very small quantity of alcohol absorbed evaporates very soon when exposed to the ordinary atmosphere, and the surface of the picture remains clear as long as a newly-varnished surface.

The most serviceable and convenient apparatus for the above purpose is some wooden case of the size required, about three inches deep, lined inside with some metal, for instance, zinc, with the exception of the lid, to which the picture or the pictures to be restored are fastened by screws in the usual manner, as in ordinary packing cases. Alcohol is then poured in the metal-lined bottom of the box or case, and the lid is shut, thus suspending the pictures face downward over the alcohol. From time to time the lid is opened, in order to watch the progress of the restoration, and to take out those paintings that have absorbed sufficient vapor. For treating a painting that could not well be removed from its place, a case without lid and metal lining is required a little larger than the painting, the bottom of which is covered inside with some absorbing stuff—for instance, flannel or the like—which is slightly sprinkled over, and thus only just moistened with alcohol, and then the case is fastened over the painting, so as to cover it completely. Of course a variety of appliances might be contrived, but they need not be described, since the newly discovered principle of self-action by vapors only is the subject of the invention. Thus, in the same manner, other substances can be used instead of alcohol—for instance, wood-naphtha, ether, sulphuric and other ethers, turpentine, petroleum, and benzine, and the various ottos; and in special cases higher and lower temperature is to be employed, but all that is but secondary and subordinate to the principle of self-action by absorption of vapor.

On Magneto-Electricity, and its Application to Lighthouse Purposes.

By F. H. Holmes.

From the Journal of the Society of Arts, Dec., 1863.

As this is a paper on the Application of Magneto-Electricity to Lighthouses, I will begin by saying a few words on lighthouses themselves, their former and present state, and the systems now generally followed in the arrangements for lighting.

Formerly lighthouses were few, and were very nearly all coal fires on high cliffs or towers, and most of them were the property of private individuals; but, as shipping increased, so the lighthouse system became more and more developed, both in the number of lighthouses and in the improvement of those already existing. The coal fire gradually gave way to the oil lamp and candles; next we find the introduction of spherical mirrors or reflectors, and these, again,

were superseded by parabolic reflectors, sometimes to the number of more than thirty in one lantern. After this came the introduction of the "Fresnel Lens," which took the place of the reflectors and their lamps, however numerous they might be, and required instead one central lamp.

This "Fresnel Lens" has again grown, so to speak, larger and larger, as the want of a more powerful light was felt, till it has now a diameter of six feet and a height of ten, for to increase the quantity of light the size of the lamp must be increased, and the lens in proportion, or it would have been so far out of focus that the intention of the lens would have been frustrated.

To make these progressive improvements in lighthouses vast sums of money had to be expended; and now let us see what was the end sought. First to improve the light itself. This is done by the substitution of a lamp of four concentric wicks, the largest nearly four inches in diameter, for the coal fire. If the improvement had stopped at that it would have been small indeed, but this lamp is more under command than the coal fire. The value of the introduction of oil is not so much, then, on account of its greater power as for its aptitude for the employment of economizing apparatus, whether this consists of reflectors or lenses. All incandescent bodies give out rays as it were from the centre to the circumference of a sphere; of such rays only those which fall on the sea would be useful to the mariner, but by means of reflectors those rays which would pass inland, or upwards, or downwards, are reflected towards any required point, and by a proper arrangement of a series of reflectors, the whole or nearly the whole of the rays directed where required. The Fresnel lens consists of a middle refracting belt, and a double series of reflecting prisms, or zones, as they are generally termed, and, when properly constructed, it has the property of collecting all the rays into one horizontal beam, so that all the light from the lamp is utilized. Thus, then, we see great strides have been made, since the introduction of oil lamps, as regards the lenticular apparatus—in fact that may be said to be nearly perfect; let us then return to the consideration of the light itself for a moment.

Whether a large or a small lamp be employed it will make no difference in misty weather, so long as the thickness of the flame is the same, for a large lamp may be equal to ten or twelve smaller ones, and, if replaced by these ten smaller, it will be evident that when one of these is obscured by mist the whole of them will be obscured. Quantity of light, then, will not add to its power of penetrating mist. By making the large lamp with four concentric wicks, the intensity of the light is a little increased, and such a lamp will penetrate further through mist in a slight degree. But it is in misty and hazy weather that the light is most required; hence, now that everything else is nearly perfect in a lighthouse, the authorities, both in this country and elsewhere, are directing their attention to the only thing wanting to make the whole system perfect, that is, a light capable of penetrating mist; and as this power depends on the intensity of the light,

and electricity is capable of producing the most intense light known, it was naturally looked to as the possible means of perfecting the whole system. But the light produced by electricity to be applicable for lighthouses must be certain and constant, not liable to extinctions or any great variations, as the first would tend to endanger vessels seeking and not finding the light; and if a fixed light had much variation, it might be mistaken for a revolving light.

Let us now see whether electricity can produce a constant, steady, or uniform light. Frictional electricity will give a succession of flashes intensely vivid, and might be used for the purpose, but for the fact that the slightest moisture is sufficient to convey the whole charge to the earth. The various forms of galvanic battery are all capable of producing a steady and intense light, but still (besides the great expense) they are not applicable, because of the necessarily varying current which becomes weaker and weaker as the solution becomes saturated. The magneto-electric machine is then the scource from which one would naturally expect a light which should be invariable in its nature and capable of being continuous for any given time, as the current produced by this machine is constant as long as the helices revolve with the same speed, and the speed can be easily regulated to any required velocity.

The electricity derived from a magneto-machine is induced in coils of wire, by the changing of the magnetic polarity of pieces of soft iron inclosed within the coils or helices; and the quantity or intensity of the induced current depends first, on the amount of magnetism induced in the soft iron; secondly, on the facility with which the poles of the magnetized soft iron can be reversed; thirdly, on the velocity with which the change of polarity takes place; fourthly, on the length and diameter of the wire forming the helices.

The amount of magnetism induced in the soft iron depends on the size and force of the steel magnets employed, and on the weight and softness of the iron in the helices; but the weight in practice of the soft iron is limited by the weight of the steel magnets, for, if too heavy the steel magnets will be slowly deprived of their magnetism. To facilitate the change of the poles the soft iron cores of the helices are not solid pieces of iron, but are tubes, single, double, or treble, as it is found by experiment that the same weight of iron, when divided in this manner, loses or takes magnetism in much less time than when in a solid form.

There is a limit to the velocity to be employed when the maximum of electricity is required, for this reason. It has been already remarked that the amount of electricity depends an the amount of magnetism taken up, and that the soft iron takes time to become saturated, as it may be termed, with magnetism; hence, if the velocity be too great with which the cores move from one pole of a magnet to another, there will not be sufficient time for the cores to become saturated. But as again the quantity of electricity increases as the velocity increases, it is necessary to ascertain this maximum point exactly, which is easily done, either by experiment or calculation, based on certain

data. The length and diameter of the wire require to be different, according to the current required; for a short thick wire forming the helices represents a galvanic battery composed of a dozen, say, of very large pairs of plates, whilst a long thin wire would represent a battery composed of thousands of small plates. In other words, supposing the size of the helices to remain the same, if they are composed of thick short wires, quantity is obtained; but if composed of long thin wires, intensity will be the result.

From all this it results that there are certain laws known and established, by which a magneto-electric machine can be made to give a current of any given amount of electricity, with any given ratio between its quantity and intensity.

Having seen on what the production of the current depends, the next point to observe is, the peculiar nature of this induced current. It differs essentially from a galvanic current in this, that while the helices are revolving, the direction of the current is reversed, as the core of soft iron passes each consecutive pole of the steel magnets.

It now remains to explain how the current generated in the wires of the helices is to be withdrawn from the machine. In the first place all the helices are connected in two, or four, or more series, and in doing this great care must be observed that the direction of the coil of every alternate helix is in an opposite direction, that is, if one is wound as a right-hand screw, the next should be as a left-hand screw, or, what amounts to the same thing, supposing all wound in the same direction, then the two inner ends of the wires must be joined of, say, numbers one and two, and the two outer ends of the wires of numbers two and three, and so on through the series; and lastly, the terminals of the series might be soldered into two insulated disks, and then led from the machine by two pieces of metal kept in contact with the outer surfaces of these disks by a slight spring; such an arrangement allows the alternating current to pass from the machine, and such a current will produce a light, but this light has certain disadvantages. It is never white, but always more or less blue or brownish; in fact it is like the electric light obscured by placing it behind a flame from spirits of wine. It is also extremely injurious to the eyes, both from its color and from its tremulousness; I therefore do not use this current but in its stead I convert this constantly inverting current into two that flow from the machine in one direction only. This is accomplished thus: One-half of the helices are arranged so as to arrive on the poles of the magnet at the instant that the other half are exactly midway between the poles. Thus there are two distinct currents; and what may be called the dead point, that is the point when the current inverts in one series, occurs exactly at the time when the other current is at its maximum, so that if now the inverted currents can be again inverted in both of these distinct currents, and that the two now flowing in one direction can be united as one compound current, it is evident that the result will be a current nearly as uniform as that from a galvanic battery, with the advantage of equable continuity.

This is done by the two commutators, which consist each of two insulated rings of metal, of such a form at the periphery that two rollers or rubbers change sides from one disk to the other at the same instant that the current is reversed. Then, by combining the two commutators, a compound current is obtained that will produce a constant white light or perform any of the other functions of the galvanic current, and in a more perfect manner, as it is more uniform in its action.

A steady and constant current thus obtained from the magneto-electric machine is only one part of the problem of producing a constant and steady light, and, although the most important part, still it would be perfectly useless without an efficient lamp or regulator. In order to understand this it is necessary to explain that the carbon points used for producing the light or for converting a portion of the electric current into light, are consumed, and that the rate of consumption is irregular, owing to the irregularities in the structure of the substance used, which is the kind of graphite deposited in the gas retorts sawed up into pencils about a quarter of an inch square; but, as the consumption is irregular, no clock-work with continuous motion could be employed for the purpose of causing the carbons to approach as consumed, for it must be understood that the steadiness of the light as well as its brilliancy depend on the two carbon points being maintained constantly at a certain distance corresponding to the strength of the electric current.

Many pieces of apparatus more or less complicated have been invented from time to time for the purpose of regulating the movements of the carbon electrodes, and many of them I have tried, but none of them, as formerly constructed, could be used in a lighthouse, because they were more or less uncertain in their action, and because the clock-work was too delicate and liable to accident in other hands than those of an electrician. The question, what constitutes a good regulator, must be answered by stating what it must accomplish; and moreover it must perform its several functions in the most simple manner. It must in the first place maintain the carbons at a given distance, whatever be the variation in the state of consumption, and must also be capable of being adjusted to any strength of current; secondly if by any accident the current should be interrupted, and the light thereby extinguished, the regulator should be capable of re-lighting at once with full brilliancy, that is, not only must it allow the carbon points to touch to re-establish the current, but must separate them again instantly, or there would be no light. Such a regulator we have here, for its construction is simple, and it forms its different functions in a most perfect manner. Its construction is this. The upper carbon is attached by a kind of small vice to a bracket, standing out from a tube, which slides freely in a column. The lower carbon is fixed in the end of another tube, exactly under the other carbon. Both of these tubes are put in motion thus: Two cords, passing over pulleys, properly arranged, are wound on one spindle, but in opposite directions. On turning a stud fixed on the end of the spindle the regulator is wound up; that is, the top bracket is raised and the lower tube depressed.

On removing the hand from the stud, the upper tube would descend, and, being loaded, would cause the lower tube to rise; but to prevent this, while the regulator is out of use a bolt is pushed in, which prevents any movement in the regulator till it is again withdrawn. The regulator being wound up, the carbons are firmly fixed in their places by tightening the holders, and are then adjusted so as to bring the points of the focal plane by turning a spindle to which the fixed end of the cord belonging to the lower carbon is attached. So far the regulator is only a means by which the carbons can mutually approach each other with a certain relative speed, depending on the different diameters of the two parts of the spindle around which the cords are wound. But if the carbon points remain in contact, there will be no light. Some contrivance, then, was necessary to separate the points to the distance, which, by experience, is found to give most light, and to maintain that distance between the points constantly till the whole of the pair of carbons is consumed. These two operations are accomplished thus: The fixed end of the cord which works the upper carbon is attached to one end of a lever; the other end of the lever has a piece of soft iron attached to it, over an electric magnet, so that when the bolt is withdrawn, and the carbon runs together until they touch (thus allowing the current to pass), this electro-magnet instantly, by the action of the same current, lifts the cord and with it the upper carbon, to the required distance. But this is not all, for the carbons would again run together were there not some contrivance to prevent them. To accomplish this, advantage is taken of these two facts—first, that the quantity of electricity is proportional inversely to the distance between the carbon points; secondly, that the strength of an electro-magnet is proportional to the quantity of electricity passing through the wire that surrounds it. Bearing these two facts in mind, it will be easy to understand the use of the second electro-magnet. Over this electro-magnet, at a small distance above it, is placed a lever, one end of which is drawn down by a spring, the strength of which can be regulated by a thumb-screw. The fulcrum is between this end and the centre. The other end of the lever is furnished with a catch, and immediately over the electro-magnet a piece of soft iron is fixed in the lever. On the carbons being allowed to touch as before, not only are they separated by the means described, but this second lever, acted on by its electro-magnet at the same instant, is drawn down towards it, and thus brings the catch between the teeth of a wheel placed under it for the purpose, and effectually locks the regulator. The strength of the spring is now adjusted till its tendency to lift the catch out exactly balances the current which draws it down. Should the distance now increase but the $\frac{1}{200}$ of an inch, the spring will be stronger than the current, will lift the catch, and the carbons will approach; by doing so, more current passes, the electro-magnet is strengthened, and is again enabled to overcome the spring and draw down the catch, and thus by their mutual action the distance between the carbon points is all but invariable.

When these regulators are employed in a lighthouse there are a pair for each lens and two small lenses, so that although it may take ten

minutes to replace the consumed carbons, still the light is never extinguished; for, suppose the carbons consumed in the lens No. 1, the regulator is ready in lens No. 2; and all the light-keeper has to do is to bolt the No. 1 regulator and draw the bolt of the regulator in No. 2 lens; the current is thus diverted, No. 2 is instantly lighted, and the lighting of this extinguishes No. 1.

Thus, then, we have a most intense light, which may be maintained for any length of time, which does not require to be trimmed or extinguished for a second, and which has all the steadiness and uniformity required for lighthouse purposes. Its advantages over the oil lamp are:—first, its power can be increased *ad libitum* without increasing the size of the lens, for, if required, a machine may be made to give light enough to read by say at 10 or 20 miles; in fact the light is in direct proportion to the power of the machine that produces it; secondly, its great intensity gives it a power of penetrating haze only equaled by the sun; thirdly, its whiteness distinguishes it most perfectly from all other lights on shore, which is one of its most important properties, for many a vessel has been lost for want of this property in lighthouses lighted with oil; fourthly, where colored lights are required for the purpose of distinguishing one lighthouse from another, this light gives all the colors in a perfect manner, while the oil lamp always gives its own tinge to the color employed; fifthly, from the facility with which this light can be extinguished in an instant, and as instantly lighted to its full power, it offers other means of distinguishing lighthouse from lighthouse which cannot be obtained with any other light. The importance of this may be understood from the fact that there are still many points around our shores that require lighthouses, but which must remain without them, till better means of distinguishing them with certainty from others in the immediate neighborhood can be employed; for having no lighthouse is hardly worse for the navigator than having two in sight which cannot be distinguished one from the other.

An objection has been made to this light, that, being so small, it would be altogether invisible at a considerable distance; and when we merely consider that the apparent size of distant objects depends on the visual angle, there seems to be some ground for the objection, but the law of visual angles does not apply in the case of self-luminous bodies, as can be demonstrated with this piece of fine wire, which I suppose is almost invisible even with a strong light thrown on it, but now, if by passing a current of electricity through it it is made self-luminous, it appears gradually to increase in diameter as it becomes brighter; and as a curious fact, illustrating the difference between the theorist in his study and the practical observer, a sailor who had seen the magneto-light from a great distance told me he supposed it must be at least ten feet in diameter. Another objection to the light is, that it is too bright; this may be an inconvenience in clear weather, but a light to be useful when most needed must be inconveniently bright in clear weather.

The last point to be considered is the cost of the magneto-electric

light as compared with oil. The French director-general of light-houses has made a report to his government, both as to first cost and as to cost of maintenance; both are greatly in favor of the magneto-electric light; of course in making their calculations of cost, they take the cost of an equal quantity of light in each case, that is by oil and electricity.

I have now only to remark that this invention, if it may be called one, is purely English; Faraday commenced it when he discovered the fact that magnetism might be made to produce or induce an electric current; and although the magneto-light was first produced in Paris, it was by me; and so far from receiving assistance from any of the French *savans* in the matter, I was ridiculed by all of them for attempting what they said they could demonstrate was impossible. With regard to the regulator, which is also invented by me, there is another just invented by a Mons. Foucault, on a very different principle, but which is quite as effective though overloaded with clock-work. His regulator has this peculiarity, it can be used in a rolling vessel, and will bear with impunity the vibrations of a steamer.

Discussion.—Mr. Lawrence suggested that Mr. Holmes should give a description of the practical arrangements of his apparatus at Dungeness lighthouse.

Mr. Holmes stated that at Dungeness, where the light had been in constant use since the 6th of June, 1862, there were in the lantern two small lenses, fixed one over the other, and two regulators to each. Only one light was shown at a time, but there were two regulators for each lens, so that an instantaneous change from one to the other could be made without extinguishing the light when fresh carbons were required. In the machine-room there were two magneto-machines, each capable of giving a powerful light, though both were in constant use. There was a distinct direct-acting steam engine attached to each machine, and there were two Cornish boilers, each capable of generating steam enough for the two engines. The material consumed at Dungeness was about 30 to 35 lbs of coke per hour, and $5\frac{1}{2}$ inches of graphite in the regulator per hour, the price of this last being under three farthings per inch. The principle item of expense was, at present, the engineer, who had charge of the whole apparatus, but he expected that when there were several lighthouses on this principle, it would be found that one engineer would be sufficient for as many as were at present under the charge of an agent, and that none but stokers and light-keepers would be required on the spot. The magneto-electric machines which were at Dungeness contained 120 horse-shoe magnets of about 50 lbs each, and 160 helices, but those which he now constructed contained only from 66 to 70 magnets, and from 88 to 120 helices.

The Chairman said he had listened with much pleasure to Mr. Holmes's very clear statement. He was glad to see present Dr. Gladstone, a member of the lighthouse Commission, and he hoped that gentleman would favor the meeting with some remarks tending to illustrate this subject, which was one of national importance. It was

most interesting to know that the little electric spark, not bigger than a pin's head, obtained by Faraday from the magnet not very many years ago, should have led to this development of power in the hands of an able and ingenious man like Mr. Holmes.

Mr. Summerlin referred to an invention of a somewhat similar character, by M. Berlioz, which, he believed, was superior to Mr. Holmes's apparatus. He would have been glad if Mr. Holmes had given some description of it.

Dr. Gladstone, F.R.S., said, as his name had been mentioned by the Chairman, he could not but rise to bear testimony to the able manner in which Mr. Holmes had brought forward this subject. During the existence of the Royal Commission, he had an opportunity of frequently witnessing the experiments made with this apparatus at the South Foreland. The Commissioners afterwards examined everything connected with the lighthouse system in France, where, at that time, when this brilliant light had been burning for half a year at the South Foreland, they were still making preliminary experiments, for they had not then overcome the irregularity of the current of electricity, and could not get a steady light. Since then they had advanced very rapidly, and orders had been given to place a double light of this description at Cape La Hève, near Rouen. The Dutch might perhaps be considered to have been before the French in the adoption of this system, and the Emperor of Brazil was probably before either. He did not think Mr. Holmes had exaggerated the power of this light or the ease with which it was managed, and he was glad to be able to say this, because they knew that an inventor, justly proud of his child, was often unconsciously disposed to give the best possible account of it. He was very glad to hear what Mr. Holmes had said with reference to the expense of an engineer being divided amongst several lighthouses, because that was the main difficulty. When the complexity of an instrument was increased, more skill was required in its management, and this necessarily led to expense. The great desideratum was to have a light which was capable of penetrating to great distances in misty or rainy weather, and in that respect this light was far superior to the Fresnel lamp, which was quite competent to send a light to the extreme horizon on a clear night. In a dense fog no light whatever was of any use; but a mere mist, or a shower of rain, the electric light could penetrate. There was abundant testimony that the lights at Dungeness and the South Foreland had been seen by the captains of steamers crossing from Folkestone to Boulogne, at a far greater distance than an ordinary oil lamp. Moreover, the intensity of this light could be augmented to any extent. Professor Faraday, in his reports to the Trinity House, had laid great stress upon this. All that was necessary was to double the number of magnets, and practically this was easily done, because there were duplicates of everything in such lighthouses, and in foggy weather it was possible to bring the power of both machines to bear upon one instrument; and in that way double the intensity of light could be obtained. Then further,—supposing the fog to be so dense that no light could

penetrate it, the steam engine on the premises might be employed to blow a horn or whistle, or to make some other noise which would serve as a direction to vessels. This had been pointed out by M. Regnault, director of lighthouses to the French Government, and was of great importance at a time when the question of fog signals was attracting so much attention.

Dr. Bachhoffner said, having been engaged in most of the patents taken out for producing the electric light, he had some little knowledge of the difficulties which had hitherto been considered almost insurmountable in producing the results which had been shown this evening. The great merit of this plan was the particular mode in which the electric light was obtained, and in this respect, as far as he had seen, Mr. Holmes had displayed a great amount of ingenuity. He confessed, when he first heard that Mr. Holmes had taken this matter in hand, he was very sceptical of his success; he did not believe that so much electric force could be obtained by the magneto-electric machine. The ingenuity displayed was very great, particularly in estimating the exact quantity of iron necessary for the core. Some years ago he (Dr. Bachhoffner) was engaged in some experiments on this subject, but he used iron wire instead of a hollow core. Mr. Holmes had spoken of the existence of liquid carbon between the two points, but this he (Dr. Bachhoffner) would be glad to have more evidence of. In using the electric light there was a deposit on one of the carbons, and with coke points pure graphite was produced, but he had great doubts as to the fact of liquid passing between the two points. A perfect automatic machine for regulating the position of the points was essential, and Mr. Holmes had mentioned that a spring formed part of this apparatus. He (Dr. Bachhoffner) was sorry there was any spring at all, or even clock-work. He thought a lamp might be constructed without a spring, and that would, in his opinion, make the machine perfect. The ingenuity displayed by Mr. Holmes up to this point would, no doubt, enable him to make an improvement in this respect. With regard to the question of cost, he did not think either the oxy-hydrogen light or the electric light would ever be useful for purposes of general illumination, for in such cases the cost of the light was a most important consideration, but for lighthouse purposes this ought not to be regarded, because the matter involved the safety of human life. Nevertheless, it would be interesting to know what was the cost of this system, light for light, as compared with other methods. He congratulated the public, the seafaring portion of it in particular, upon this valuable application of electric power, which at one time he thought hardly possible of accomplishment.

Mr. Holmes said the cost of this light compared with oil had been gone into by M. Regnault, director-general of lighthouses in France, and he had calculated very fairly on the principle of light for light, and, reckoning in this way, including the expenses of alteration, taking down the large lens and putting in two smaller ones, putting up the apparatus, two steam engines complete, and the buildings to contain them, the whole of the cost was calculated at half that of an

ordinary first-class lighthouse, light for light. They would quite understand the actual expense was greater than in an ordinary lighthouse, but when the quantity of light was considered, it was less by one-half, whilst the working expenses was only one-third. The light at Dungeness, he calculated, was equal in quantity to 14 of the large oil lamps with four concentric wicks. With regard to the intesity of the light, there was no form of combustion, and no chemical action which could produce a light—explosion was a different thing—beyond a certain amount of intensity. The greatest was that obtained upon lime, because the hydrogen and oxygen gases, burnt together, approached as nearly as possible to an explosion. With regard to the small size of this light, it might be argued that so small a light would become invisible at a great distance, say 30 or 40 miles. If an object three feet in diameter appeared to be only an inch at the distance of a mile, what must this little point of light be at a long distance? He admitted there was something in this argument when based on the theory of the visual angle only, but it did not apply to luminous bodies. [Mr. Holmes illustrated this by showing a thin wire, which was almost invisible till rendered incandescent by a current of electricity, when its apparent diameter was greatly increased.]

The chairman said the next duty which devolved upon him was the agreeable one of proposing a vote of thanks to Mr. Holmes for his valuable paper. He was quite sure they had heard with satisfaction what had been stated by Dr. Gladstone, who had had opportunities of examining on a large scale the methods of illumination at present practised, and he was sure every remark from that gentleman would have great weight with those present. The power which this light possessed of penetrating to a great distance constituted its superiority to any system of lighting now in use; and it was to be borne in mind that that was dependent upon the extreme intensity of the heat evolved. It had been correctly stated by Mr. Holmes that of all the lights produced by chemical means, that of the combustion of hydrogen and oxygen gases upon a ball of lime was the most intense; but electricity was far more intense than any chemical action. By its means they could fuse the most refractory metals, and convert into vapor substances which could not be volatilized by other means. With regard to the precise condition of the carbon as it passed from point to point there might be a difference of opinion. He thought it doubtful whether it was liquefied. He could corroborate the statement of Dr. Bachhoffner as to the complete conversion of the carbon into graphite when coke was employed. Mr. Holmes was greatly to be congratulated on the manner in which he had contrived to economize the power of his currents. He had by an ingenious method detected the means of indicating the exact quantity of magnetism residual in the magnet. Another curious result which Mr. Holmes's practical experience enabled him to effect, was the proportioning the weight of the armature to the size of the steel magnet, so as to avoid diminishing its power. This was one of the most curious results in the science of magnetism that had been produced in the course of this inquiry. An opportunity

had been presented to Mr. Holmes of making experiments on a grand scale, which could not be done in the laboratory of the chemist. The practical man followed the theorist, and hence there arose a harmonious co-operation between the two in the advancement of science. He congratulated the Society upon having had so valuable a paper brought before them.

The vote of thanks was then passed.

The paper was illustrated by a display of Mr. Holmes's arrangement of the electric light as used in lighthouses. Some reflectors and oil lamps were kindly lent by Mr. R. C. Wilkins, with the view of showing the various systems employed in lighthouses at different periods.

Pro. Society of Arts, Dec. 2, 1863.

Allen v. *The Steam Boiler Assurance Company.*

From the London Mechanics' Magazine, July, 1864.

This was a somewhat curious action arising out of a recent boiler explosion at Nottingham, in which

Mr. Overend, Q C., and Mr. Wills appeared for the plaintiff; and Mr. Field, Q.C., and Mr. Beasley for the defendant.

For many years past the question as to the causes of boiler explosions has occupied the attention of manufacturers and scientific men, and every effort has been made to render them as unfrequent as possible. They are still, however, so frequent that the defendants have established themselves for the purpose of insuring manufacturers against losses arising from explosions. In their policies the defendants exempt themselves from liability in respect of accidents arising from "wear and tear;" and in the present case the only question was whether the accidents in question arose from "wear and tear," so as to exempt the defendants from liability. The boiler in question was supplied by and put up under the personal superintendence of the defendants engineer. After lasting, however, only three years, instead of ten years, which was said to be the average duration of boiler-life, it burst—happily, however, without causing loss of life, or doing any material damage.

The case on behalf of the plaintiff was that the boiler was faulty in construction and badly erected. It was shown in evidence that the boiler had always leaked from the time it was first put up, and that the iron consequently corroded until it became so weak that a pressure of 13 lbs. to the inch was sufficient to burst it. It was also shown that the boiler was of a kind peculiarly liable to accidents. The base of the boiler was placed in the fire, and the pressure of steam forcing the water upwards, and leaving a steam space at the bottom, the base of the boiler was left without water, and was always, therefore, more liable to corrode and burst than in the case of a boiler the base of which is placed under the fire. It was contended that if the defendants were not liable in the present instance it would be impossible to imagine a case in which they were liable.

For the defendants, evidence was given of scientific men, who gave it as their opinion that the plaintiffs workmen had been negligent in

their care of the boiler, and that the accident had arisen from "wear and tear." It was contended for the defendants, that if they were liable in such a case as the present, the result would be that they would have to keep in repair the boilers of all persons who insured with them.

The jury found a verdict for the plaintiff.

On Punching and Drilling Rivet holes.

From the London Mechanics' Magazine, August, 1864.

Probably the liveliest discussion which arose upon the several papers read at the meeting of the Mechanical Engineers at Glasgow, turned upon the comparative advantages of punching and drilling in making rivet holes. Mr. Fletcher, the veteran tool-maker (and a partner in the house of Messrs. William Collier & Co.), had prepared a very able paper, in the course of which he properly gave the preference to drilled as compared with punched rivet holes. He described the defects of ordinary punching, not perhaps with especial originality, inasmuch as these defects are so well known, and have been so often discussed, that little that is new could be said of them. The process of punching is a rough, and we may say, a barbarous mode of making a hole in an iron plate. A series of holes, too, in a row, can hardly be punched with that degree of accuracy which is necessary in modern boiler-making and bridge-building. We are here speaking only of accuracy of line and pitch, for no punched hole is in itself cylindrical or smooth. Mr. Roberts's jacquard punching machine secured, it must be owned, a degree of accuracy before unknown in punching bridge plates, and it was employed with success for punching the plates of the Conway, the Victoria, the Boyne, and the Jumna bridges, and, more recently, upon the Menangle and Penrith bridges for the Great Southern Railway of New South Wales. But admirable as is the ingenuity displayed in the jacquard machine (and that now at the Canada Works, Birkinhead, is the only one which the late Mr. Roberts ever made), it must be owned that it would have accomplished even better work had it been a drilling instead of a punching machine. Besides, whatever want of truth and accuracy there may be in ordinary punching, it is believed that the action of the punch strains, and thus weakens the iron. Few, we think, employ punches which exactly fit their dies, and therefore the operation of punching does not give the clean shearing cut which is commonly counted upon. An examination of a plate which has been only half punched through will at once show how much the punch distorts, and therefore of necessity strains the iron upon which it acts. No iron can be once strained beyond its limit of elasticity without injury, or, in other words, without being made weaker ever afterwards. Yet an ordinary punch does strain the iron surrounding the punched hole, and to an extent which Mr. Fairbairn has estimated pretty closely from the results of experiments upon punched plates. Although with 11-16 in. rivet holes of

1¾ in. pitch, less than 40 per cent. of the iron is removed by punching, the single riveted joint loses at least 44 per cent. of the strength of the solid plate. This, too, is the result, notwithstanding the friction at the lap of the plates, which thus gives each plate a certain hold upon the other. We believe Mr. Fairbairn's experiments showed a loss of strength in the iron left between the holes punched in a row equal to about fifteen per cent. of the strength of the same net section of iron before punching. With very thick plates the injury by punching is greater, we believe than with thin plates. The French engineers prefer very thick iron for large locomotive boilers, and for those, 5 feet in diameter, of the largest Engerth engines, iron of 15 millimetres, or 6-10 in. thickness, is employed. Here we believe the loss of strength by punching amounts to something considerable, and we can say that, in some of the French bridge-work, we have seen three consecutive rivet holes cracked out to the edge of the plate under the combined action of punching and riveting. A series of experiments, made by a committee of Lloyd's, with reference to the strength of the riveted plating of iron ships, went to show that a joint in 3-8 in. iron was absolutely as strong as one in ½-in. iron, the loss of the whole strength, due to riveting, being only 40 per cent. in the first case, and nearly 60 per cent. in the second. If, instead of trusting to general opinions, engineers chose to investigate by actual experiment the effect of punching upon the strength of iron plates, they would, we believe, have reason to abandon punching to a great extent, if not altogether. The drill makes a clean cut, without the chance of injury to the iron, and in this way its employment must add greatly to the strength of riveted structures, and that extra strength is quite irrespective of the additional strength obtained by the certainty that the rivets exactly fit the rivet holes, and that the holes are exactly coincident in opposite plates without the use of the drifting tool. Rivet holes are now drilled with nearly the rapidity with which they can be punched. Mr. Fletcher, at the Glasgow meeting, described a machine upon the general construction adopted a few years ago by Messrs. Cochrane for drilling the plates of the Charing Cross-bridge, and he mentioned the fact that this machine drilled all the holes in a large plate of 1 in. thickness in fourteen or fifteen minutes only, all being drilled at one operation. By powerful hydraulic pressure, worked from an accumulator, each drill is pressed with a force of about 6 cwt. but by increasing the pressure the whole plate may be drilled in the short space of 3½ minutes. Mr. Adamson, the eminent boiler-maker of Hyde, stated that he found the drilled plates much better, in respect of strength and tightness of the joints than those punched in the ordinary manner, and he anticipated that, within a year or so from the present time, every boiler plate worked up in his factory would be drilled instead of being punched. With a far-seeing judgment of the requirements of an improved practice, Mr. Adamson added that he had still greater confidence in welded seams; and we may conclude that this grand improvement, occasionally resorted to by Bury, Hack-

worth, and others, will eventually come into general use in the case of boilers made of plate iron.

There were those, however, at the Glasgow meeting, who contended stoutly that drilled rivet holes were in no respect superior to those punched in the ordinary manner. We are unwilling to refer personally to the speakers who supported this view, but they had no facts whatever in support of their assertions upon this point, beyond the negative proof that boilers made with punched holes had not yet blown up, nor bridges, with holes thus punched, yet broken down. This argument, however it may commend itself to a certain class of practical men, is not that upon which the question is to be discussed. No one pretends that bridges are in danger of breaking down merely because their rivet holes are punched, and therefore no question of this kind is at issue. The only question is, do punched holes leave as much strength, and are they as consistent with tightness and general excellence of workmanship, as those drilled with the improved machinery? It is no proof because a bridge has not broken that it is as it might be made with the same materials. The necessity for the utmost strength, both of the materials and of their combination in bridges, boilers, and ships, is now more widely recognised and insisted upon than heretofore. Not only are we building numerous bridges of great span, but the weight of railway trains is increasing, not merely when taken collectively, but when weighed over each foot of line covered. So with boilers; while the whole sizes are still retained, there is a tendency to increased pressures; and in the case of iron ships, no amount of strength consistent with lightness is too great. We shall have an additional guarantee of safety when all riveted work, to which the security of human life is confided, is carefully drilled instead of being punched, and yet we have to confess to a wonder that the representatives of great houses should, both at Glasgow and at the late meeting of the South Wales Engineers, contend that punched plates were as strong as, if not stronger than, those drilled by special machinery.—*Engineer.*

Process for Preserving Flowers.

From the London Artizan, Dec., 1864.

Mr. C. R. Tichborne states that, being desirous of preserving a vegetable *lusus naturæ* for some time, he submerged it in some weak glycerine, considering that that fluid would be less likely to destroy the tender organism, and also remembering that it had been found most efficient in the preservation of animal tissues. The glycerine answered its purpose most admirably, preserving the delicate parts of the plant and preventing decomposition. He immediately saw that this property of glycerine might be made available for certain pharmaceutical purposes, where it was desired to preserve or extract the aromata of vegetable products, such as elder, orange, or rose flowers, and also might be substituted for the oils and fats used in the purest process termed enfleurage. The glycerine need not be especially pure, but should be devoid of odor. The elder-flowers should be gathered

when the corolla is fully expanded, but not too far gone; they should then be plucked from the stem, and packed firmly in wide mouthed bottles or jars, without crushing them; and the whole should then be covered with glycerine. Mr. Tichborne states that he has thus preserved flowers for two years, and, on distilling them, procured a water the perfume of which has equalled the most recent product. For the preservation of the aroma of the flowers he considers the employment of glycerine far superior to the system termed enfleurage, in which heat is used.

Translated for the Journal of the Franklin Institute.

Welding Iron by Hydraulic Pressure.

M. B. Duportail, an engineer, has been trying experiments upon the application of hydraulic pressure to forging and boiler-making. His experiments were especially directed towards the welding of iron under the hydraulic press, by which a permanent and almost indefinite pressure is produced, by which the welding is effected throughout the mass of the iron, and not merely at a small depth as under the forge hammer. In his last experiments Mr. D. welded, without previous preparation, two pieces of iron, $1\frac{1}{2}$ inches square, after heating them to a white heat. The operation took place with the greatest ease, the iron was moulded like dough, and spread out at the sides whilst the pressure was in action. The pressure was stopped when the thickness at the joint was equal to that of the bars. After cooling, the piece was split in two for the purpose of examining the weld. The appearance was excellent, and one of the two pieces was put under a hammer of a ton and three-quarters and struck three times, cold. The weld showed itself only under the second blow and was not completely opened by the third. *Cosmos.*

Translated for the Journal of the Franklin Institute.

Preparation of Aluminium.

M. Corbelli has found a simpler and more economical process for procuring aluminium than that heretofore used. The metal is prepared from clay first carefully purified from foreign matter,—then dried and treated by an acid to remove iron. About six times its weight of sulphuric acid will answer this purpose. The clay is then allowed to settle, dried again, and mixed with about twice its weight of Prussiate of potassa, the quantity of which is to be increased or diminished according to the content of silica in the clay. To this mixture, one and a half times the weight of the clay, is added of common salt; the mixture placed in a crucible and heated to a white heat. After cooling, the aluminium will be found at the bottom of the crucible. *Cosmos.*

Translated for the Journal of the Franklin Institute.

A New Method of Hardening Cast Iron.

A patent has just been taken out (in France), for a method by which cast iron may be made as hard as tempered steel. When the object in cast iron has been filed up and completely finished, it is to be heated to cherry-red, and plunged until it is cold again in a solution containing 1080 grammes (70 ozs. troy) of sulphuric acid, and 65 grammes (4 ozs. troy) of nitric acid to 2½ gallons of water. The thickness of surface hardened is sufficient for ordinary wear, and the form of the object is not at all altered. *Cosmos.*

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, November 17th, 1864.

William Sellers, President, in the chair.

Washington Jones, Recording Secretary.

The minutes of the last meeting were read and approved.

The Board of Managers and Standing Committees reported their minutes.

The Board of Managers reported resolutions passed at their last meeting for regulating the scientific proceedings of the Institute, which were read and approved by the Institute.

In accordance with the second resolution, the President appointed a standing Committee to have charge of the scientific proceedings consisting of the following gentlemen, viz.

Prof. Fairman Rogers, J. Vaughan Merrick, Esq., Prof. John F. Frazer, Coleman Sellers, Esq., and Prof. Henry Morton.

The Special Committees on Weights, Measures, and Coinage, of the United States; on Steam Expansion; and on a uniform system of Screw-threads and Bolt-heads, and Nuts, reported progress.

Robert Briggs, Esq. called the attention of the meeting to the proposed establishment of a new Institution in Boston, Mass., under the title of the "Institution of Technology." He stated the amount of donations already contributed in money and land for the purpose, and submitted two pamphlets published on the subject, one entitled "Objects and Plan of an Institute of Technology including a Society of Arts, a Museum of Arts, and a School of Industrial Science;" and the other, "Scope and Plan of the School of Industrial Science of the Massachusetts Institute of Technology.

Prof. Fairman Rogers made some remarks on the manner of conducting the examinations in the school of Technology at Cambridge, Massachusetts.

Mr. Thomas Shaw called the attention of the Institute to the importance of a uniform system of Sound Signals to be used on railroads, and moved a resolution referring the subject to the Committee on Sci-

ence and the Arts to be investigated by them, and report to the Institute.

Mr. Samuel Dunseith exhibited specimens of Leather, tanned by his patented process, which is as follows:—

The skins are first treated in the usual manner adopted by practical tanners.

The tanning composition is prepared by making a decoction of the plant known as Golden Rod (Solidago), and dissolving in the same a sufficient quantity of "Cuch," or "Catechu," alum, nitre, and salt.

The skins are then introduced into the tanning liquor, which should be maintained at about 15 degrees barkometer standard, until the tanning is completed. Calf skins and kips can be tanned in from 8 to 14 days, and ox skins in from 20 to 90 days.

Holt's Patent Ribbon Hand Stamp was also exhibited. In this stamp a chemically prepared silk ribbon furnishes the coloring matter, and as it will never dry, gum-up or evaporate, the stamp is always ready for use, and the ordinary troublesome pads, brushes, &c. are dispended with.

J. Harrar's Improved Skate Fastening was exhibited. This fastening is intended as a substitute for the plates heretofore used for securing the shoe to the heel of the boot, the proper adjustment of which is a matter requiring considerable labor.

The improvement consists of a small malleable iron hollow cylinder screw, to adjust which it is only necessary to bore a hole in the boot-heel with a half-inch bit, and screw the cylinder into the same.

Mr. Longstreth exhibited J. M. Naglee's Improved Syphon. The short stem of the syphon is bent at its upper end, and connected to the top of a reservoir, from the lower side of which projects the long stem the latter having a cock at its lower end. At the top of the reservoir is a funnel between which and the reservoir is a cock.

The reservoir and longer stem of the syphon are filled through the funnel, with the fluid to be discharged, and when thus filled contains such a quantity of the fluid that before all has been discharged a partial vacuum is formed in the short stem through which the fluid is thus caused to flow into the reservoir.

ERRATA.

In Vol. xlvii.—June, 1864.—"*Robinson on Arch Truss Girders.*"

Page 363, line 11 from bottom for "*ridged*" read "*rigid.*"
364, " 8 " " " "*toward diminishing*" read "*to diminish.*"
" " 5 " " " "*have their*" read "*has its.*"
365, " 15 " top " "*their*" read "*its.*"
366, " 25 " " " "G.F." read "J.G."
368, " 8 " " " "*diminish*" read "*diminishes.*"

A Comparison of some of the Meteorological Phenomena of NOVEMBER, 1864, *with those of* NOVEMBER, 1863, *and of the same month for* FOURTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich. By J. A. KIRKPATRICK, A. M.

	November, 1864.	November, 1863.	November, for 14 years.
Thermometer—Highest—degree, .	69·00°	69·00°	80·00°
" " date, .	30th.	5th.	1st 1860.
" Warmest day—Mean,	65·17	60·50	72·30
" " " date,	9th.	5th.	9th 1857.
" Lowest—degree, .	25·00	25·00	16·00
" " date, .	24th.	30th.	25th 1860.
" Coldest day—Mean,	28·83	30·50	23·30
" " " date, .	23d.	30th.	25th 1860.
" Mean daily oscillation,	10·80	14·37	13·27
" " " range, .	5·84	6·35	5·71
" Means at 7 A.M , .	41·30	42·45	41·18
" " 2 P M., .	49.22	52·63	50·29
" " 9 P.M., .	44·57	46·12	44·41
" " for the month,	45·03	47·07	45·29
Barometer—Highest—Inches, .	30·347 in.	30·249 in.	30·661 in.
" " date, . .	25th.	23d.	12th 1851.
" Greatest mean daily press.	30·321	30·232	30·520
" " date, . .	24th.	23d.	12th 1851.
" Lowest—Inches, .	29·080	29·434	29·080
" " date, . .	4th.	17th.	4th 1864.
" Least mean daily press.,	29·150	29·498	29·150
" " date, . .	4th.	17th.	4th 1964.
" Mean daily range, .	0·208	0·185	0·186
" Means at 7 A.M., .	29·848	29·863	29·909
" " 2 P.M., .	29·803	29·804	29·866
" " 9 P.M., .	29·849	29·854	29·897
" " for the month, .	29·833	29·840	29·891
Force of Vapor—Greatest—Inches,	0·548 in.	0·463 in.	0·832 in.
" " " date, .	10th.	15th.	8th 1857.
" " Least—Inches, .	·082	·074	·055
" " " date, .	24th.	10th.	25th 1857.
" " Means at 7 A.M., .	·218	.208	·225
" " " 2 P.M., .	·227	·214	·230
" " " 9 P.M., .	·227	·216	·233
" " " for the month,	·224	·213	·229
Relative Humidity—Greatest—per ct.,	94·0 per c.	97·0 per c.	100·0 per c.
" " " date,	7th.	15th.	often.
" " Least—per ct.,	30·0	25·0	25·0
" " " date, .	30th.	7th.	7th 1863.
" " Means at 7 A.M.,	76·2	73·7	77·4
" " " 2 P.M.,	60·9	52·2	59·0
" " " 9 P.M.,	72·2	66·0	73·5
" " "for the month	69·8	64·0	70·0
Clouds—Number of clear days,* .	5	6	8·2
" " cloudy days, .	25	24	21·8
" Means of sky cov'd at 7 A.M.,	72·7 per c.	57·3 per c.	60·8 per c.
" " " " 2 P.M.,	73·0	54·3	60·9
" " " " 9 P.M.,	59·7	52·3	53·0
" " " for the month,	68·5	54·6	58·2
Rain.—Amount,	4·065 in.	2 960 in.	3·778 in.
No. of days on which Rain fell,	13.	7·	10·6
Prevailing Winds—Times in 1000	s83° 40′w·269	s82°46′w·371	s72°44′w·265

* Sky one-third or less covered at the hours of observation.

A Comparison of some of the Meteorological Phenomena of the AUTUMN *of* 1864, *with that of* 1863, *and of the same Season for* FOURTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich. By J. A. KIRKPATRICK, A. M.

	Autumn, 1864.	Autumn, 1863.	Autumn, for 14 years.
Thermometer—Highest—degree, .	81·00°	83·00°	95·00°
" " date, .	Sep. 24th.	Sep. 7th.	Sep. 12th '51
" Warmest day—Mean,	75·00	77·17	85·20
" " " date,	Sep. 24th.	Sep. 7th.	Sep. 6th 1854
" Lowest—degree, .	25·00	25·00	16·00
" " date, . .	Nov. 24th	Nov. 30th.	Nov. 25th '60
" Coldest day—Mean,	28·83	30·50	23·30
" " " date, .	Nov. 23d.	Nov. 30th.	Nov. 25th '60
" Mean daily oscillation,	12·09	15·04	15·10
" " " range, .	5·07	5·17	5·27
" Means at 7 A. M., .	51·54	51·27	51·66
" " 2 P. M., .	59·79	61·73	62·57
" " 9 P. M., .	54·69	55·00	55·43
" " for the Autumn,	55·34	56·00	56·55
Barometer—Highest—Inches, .	30·347 in.	30·312 in.	30·661 in.
" " date, . .	Nov. 25th.	Sep. 23d.	Nov. 12th '51
" Greatest mean daily press.	30·321	30·244	30·520
" " date, . .	Nov. 24th.	Sep. 23d.	Nov. 12th '51
" Lowest—Inches, . .	29·080	29·281	29·012
" " date, . .	Nov. 4th.	Sep. 18th.	Oct. 26th '57
" Least mean daily press.,	29·150	29·460	29·059
" " date, . .	Nov. 4th.	Sep. 18th.	Oct. 26th '57
" Mean daily range, .	0·147	0·136	0·150
" Means at 7 A. M., .	29·783	29·908	29·927
" " 2 P. M., .	29·746	29·862	29·886
" " 9 P. M., .	29·790	29·906	29·912
" " for the Autumn,	29·773	29·892	29·908
Force of Vapor—Greatest—Inches,	0·741 in.	0·784 in.	0·991 in.
" " " date, .	Sep. 24th.	Sep. 17th.	Sep. 6th 1854
" " Least—Inches, .	·082	·074	·055
" " " date, .	Nov. 24th.	Nov. 10th.	Nov. 25th '57
" " Means at 7 A. M.,	·313	·311	·336
" " " 2 P. M.,	·317	·324	·354
" " " 9 P. M.,	·327	·328	·355
" " " for the Autumn,	·319	·321	·348
Relative Humidity—Greatest—per ct.,	97·0 per ct.	97·0 per ct.	100·0 per ct.
" " " date,	Sep. 5th.	Nov. 15th.	often.
" " Least—per ct.,	30·0	25·0	23·0
" " " date, .	Nov. 30th.	Nov. 7th.	Oct. 21st. '59
" " Means at 7 A.M.,	74·5	75·1	77·9
" " " 2 P.M.,	57·5	53·8	57·1
" " " 9 P.M.,	70·8	69·2	73·6
" " " for Autumn,	67·6	66·0	69·5
Clouds—Number of clear days,* .	25	26	29·1
" " cloudy days, .	66	65	61·9
" Means of sky cov'd at 7 A.M.	63·3 per ct.	57·3 per ct.	57·7 per ct.
" " " " 2 P.M.	69·5	55·6	56·3
" " " " 9 P.M.	47·3	44·5	43·0
" " " for Autumn,	60·0	52·5	52.3
Rain—Amount, . .	13·111 in.	6·601 in.	10·705 in.
No. of days on which Rain fell,	34·	24·	27·7
Prevailing Winds—Times in 1000,	s.83°48′w·253	N75°50′w·201	N78°13′w·228

*Sky, one-third or less covered at the hours of observation.

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